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By H. J. QUAYLE.

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MOSQUITO CONTROL WORK IN CALIFORNIA.

By H. J. QUAYLE.

Introductory.—The campaign against mosquitoes recorded in this Bulletin was undertaken by the California Experiment Station at the urgent request of the Burlingame Improvement Club. Late in May, 1904, a letter was received by the entomologist of the Station, asking for aid in relief from mosquitoes in the vicinity of Burlingame, where they had become exceedingly abundant and annoying. This request was made too late to do any effective control for that season, but it was recommended that a preliminary survey be made with a view to obtaining data for future work. The writer was consequently detailed to make this survey, and three weeks were spent in the neighborhood making collections and locating breeding grounds. In this study it was soon determined that the mosquito giving practically all of the trouble (estimated at 95 per cent) was a species that bred in salt or brackish water only, and that in any work looking toward control, the salt-marsh area must receive first consideration. This being known, the preliminary report made to the Burlingame Improvement Club gave but little encouragement, because of the extent of the marsh land that must be included in the problem. It was further stated, however, that if they were considering the problem in earnest, and wished to go to the expense necessary to control this large breeding ground, the Experiment Station would be glad to outline a plan of campaign for the following season.

Nothing more was heard about the matter until early in August, when, owing to the excessive abundance of mosquitoes, due to the emergence of a brood on the marsh, Mr. G. A. Pope, president of the Burlingame Improvement Club, wrote again to the Station, asking if it would not be possible to at least mitigate the nuisance immediately. In reply to this communication it was stated that the mosquitoes now flying about would remain well up to the close of the season, and that the prevention of other broods from appearing would not lessen the numbers to any perceptible degree. It was proposed, however, that a class of students from the University make weekly trips to the territory, in order to secure more data as a roundation for the practical control work. Such a course was, therefore, announced in the University curriculum, and some half dozen

advanced students in entomology thus availed themselves of the opportunity of getting acquainted with the practical side of the subject.

In the middle of February, 1905, the writer met with the members of the Burlingame Improvement Club in San Francisco and outlined a plan of campaign. In this plan it was recommended that, in so far as possible, the work be of a permanent nature, such as ditching and filling in, this to be supplemented by oiling, where it was necessary to keep ahead of the developing mosquitoes, or where permanent work would be done only at great expense. After estimating the amount of ditching necessary on the marsh, the expense of repairing dikes and the use of oil and other materials necessary, the minimum expenditure was placed at $2,000. When this was submitted to the Club it received a unanimous indorsement, and the consensus of opinion was that the mosquito must go at any cost. Having this assurance of moral and financial support we were ready to begin the active work of the campaign at once, and a gang of men was immediately set to work.

The chief aim of the campaign was to get results in the control work, and demonstrate to the people of the State in general, and of this territory in particular, that the mosquito nuisance can be checked if the people only take up the problem in sufficient earnestness. The funds were contributed with this end in view, and, consequently, practically all of our energies were taken up with this phase of the problem, and there was little time left for a purely biological study, such as we would liked to have carried on. However, many interesting things were observed, and some additions made to our knowledge of the species concerned.

Acknowledgments.—An expression of thanks is extended to the members of the Burlingame Improvement Club, who made the campaign possible, and particularly to their president, Mr. G. A. Pope, whose encouragement and coöperation were greatly appreciated. Thanks are also due the trustees and principal of the San Mateo High School for allowing us the use of a room in the high school building for laboratory purposes, and to Attorney George C. Ross, of Redwood City, for the use of a room in his building at Millbrae for headquarters of the campaign in that section. Mention should be made also of the Trustees of the city of San Mateo and the Board of Supervisors of the county for their part in the cause in the way of legislation.

SOME COMMON FACTS ABOUT MOSQUITOES.

Since the present Bulletin is the first publication issued by the Experiment Station on the subject of mosquitoes, and in order to correct some erroneous ideas which prevail over the State regarding, particularly, their breeding places and habits, an account of the better

known facts, modified to apply to conditions in the bay region of the State, is inserted here.

Life History.—The eggs of mosquitoes are laid, either singly or in raft-like masses, in quiet water, which may be either fresh or salt, or in the mud of drying pools. This latter situation, so far as observed, is selected only by the salt-marsh species, and was first observed by Professor Smith, of New Jersey, for the common salt-marsh species (*Ochlerotatus sollicitans*) of the Atlantic Coast, and was also determined by us for our common species (*O. lativittatus*) about San Francisco Bay. The eggs hatch in from one to four days, depending upon the species and temperature conditions, and there emerges from the egg an active creature popularly known as a "wriggler," which is the larval stage of the insect.

This larval stage is passed in water, and not in alfalfa fields, freshly sprinkled lawns, cypress hedges, and other equally impossible places, as has been strongly maintained by many people whom we have met with during the past year or two, among whom may be mentioned a well-known Horticultural Commissioner, whose office is supposed to require a certain knowledge of insects. Mosquitoes occurring in alfalfa fields or recently sprinkled lawns may be accounted for from the fact that they are attracted to moisture, but that they actually breed in some water, possibly in the immediate neighborhood; in the case of the alfalfa field it may be in the irrigation ditch. They gather about cypress hedges in order to seek shelter from the strong winds. To one who is familiar with the anatomy of the young mosquito it is difficult to conceive of them occurring anywhere but in water. The mouth parts of the larval mosquito consist of a pair of hair-like brushes, which are kept in motion most of the time, and their action is such that a current of water, with all the small organisms that go with it, is directed to the mouth and thus the larva gets its supply of food. Although living in the water the larva is air-breathing, and obtains this air by projecting a tube, situated on the posterior end of the body, just above the surface film. Failure to obtain this supply of air very soon results in the insect's drowning, and this largely explains the effect of an insecticide, such as an oil, upon the surface of the water. The oil forms an air-proof film over the surface which the larva can not penetrate with its breathing tube. Thus the air supply is shut off; besides, the oil itself undoubtedly acts directly upon the larva, as may be inferred from the twisting of its body when it strikes the oil.

After molting or shedding its skin two or three times we have a creature which looks like a larva coiled up at one end, and in this stage it is the pupa. Now, instead of breathing through a single respiratory tube at the end of the body, it breathes by means of two respir-

atory siphons on the thorax. It may still be called a wriggler in this stage, since it is capable of movement and will rapidly dart away from its characteristic position at the surface of the water when disturbed. Locomotion in this stage is accomplished by means of its flexible abdomen, which bears at its tip a pair of swimming flaps. The larval life of a mosquito lasts from one to three weeks, and the pupal stage from two days to a week, depending upon the species and the temperature and food conditions.

The adult winged mosquito emerges through a rent in the skin of the pupa, and, after resting on this old discarded skin long enough to dry its wings, it flys away, a fully developed insect, ready to begin its active warfare upon man and other warm-blooded animals. It is only the female, however, that seeks this source for its food supply, the males not having developed a thirst for blood, and subsisting largely upon the juices of plants. The length of life of the adult winged mosquito can at best only be approximated, but observations made during the season just past show that they may live for three months, although the great mass of them die in the course of three or four weeks. The entire life cycle, therefore, may vary from two or three weeks to as many months.

The number of broods appearing in a season depends upon the species and the climate; the marsh mosquito, *Ochlerotatus lativittatus,* in the San Francisco Bay region, was observed to produce a brood each month from February to September inclusive, making eight in all, while the common fresh-water form, *Theobaldia incidens,* breeds practically the year round in this region. Mosquitoes may pass the winter in either of the three stages—egg, larva, or adult. The marsh species, *O. lativittatus,* passes the winter in the egg state, while other species of the sub-family *Culicinae* and one of *Anopheles* were found hibernating.

Where Mosquitoes Breed.—In brief, mosquitoes will breed in any quiet water; the water may be very foul or it may be very clean. They are not found in large bodies of water, except, possibly, near the edges, but the small, insignificant pools are their favorite haunts. Not a few people at Burlingame and Millbrae believed their mosquitoes came from the Spring Valley lakes, and it was not until the present campaign was carried well into the summer that they were convinced of their error. On account of the continual rippling of the water in these large bodies, and also because of the fact that fish are usually present, no mosquitoes are found, barring the borders, in such situations. A very general breeding ground in the bay region of California is furnished by the numerous creeks from the hills, drying up with the cessation of rains and forming pockets and other stagnant pools along

their course. Small containers of water, such as pails, barrels, or even a tin can, may also furnish sufficient annoyance for a family during a season.

Migrations.—People living in the vicinity of salt marshes must look beyond their immediate neighborhood, and decide whether or not a marsh at a considerable distance away is not furnishing them with their supply of mosquitoes. This makes the problem of control work much more difficult in such regions, and little can be done without a general movement in which the whole community participates. The salt-marsh mosquito in New Jersey has been known to migrate thirty or forty miles, and we have observed our California species at least ten miles from any breeding ground. The wind is an important factor here, and usually such migrations occur only with a favorable wind. For example, the Burlingame mosquitoes came from the marsh to the north, from where the wind could easily carry them into the district.

Collecting and Studying Mosquitoes.—The collecting of larvæ and pupæ is best accomplished by means of a small net, as shown in Fig. 1. This net is made by bending a heavy wire in the form as shown, the ends being soldered into a ferrule to receive the handle, and over this frame is soldered a wire screen of fine mesh. It is an advantage to have the wire tight for the easy transfer of the materials to the vials. A net measuring four or five inches across was found to be the most convenient size, a larger net not being easy to manipulate among vegetation or in small pools or cracks. To transfer the specimens into vials a small camel's-hair brush will be found most convenient, or, in the absence of this, the mouth of the vial may be placed so as to inclose them and the insects washed in by the water of the vial. Eight-dram homo vials are suitable for the larvæ, and these should not contain too much water, and should be brought to the laboratory with as little jarring as possible, else the specimens will drown. A few may be reared in these vials, but if there is a quantity, or the specimens are newly hatched, they should be transferred to larger vessels where there is a greater food supply.

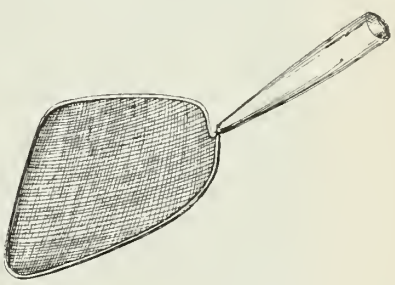


FIG. 1. Insect net.

For preserving larvæ for future study they should be killed with hot water and run through the grades of alcohol and finally preserved in 95 per cent alcohol. A mixture which was found to preserve the form and color well consisted of 5 per cent of glycerine, 2 per cent of formalin, and water. Larval skins should be preserved for studying the chitinous parts, or in the absence of these, specimens may be treated in weak potash solution.

The adults may be collected by means of vials, which are placed over the specimens as they are resting upon the hands or clothing, or by means of the ordinary insect net. The latter way should be used especially for collecting males in the vicinity of the breeding ground. Of course, the most preferable means of securing the adults is to rear them from the larvæ. They should be mounted immediately after being taken, either on small paper triangles or with very fine pins.

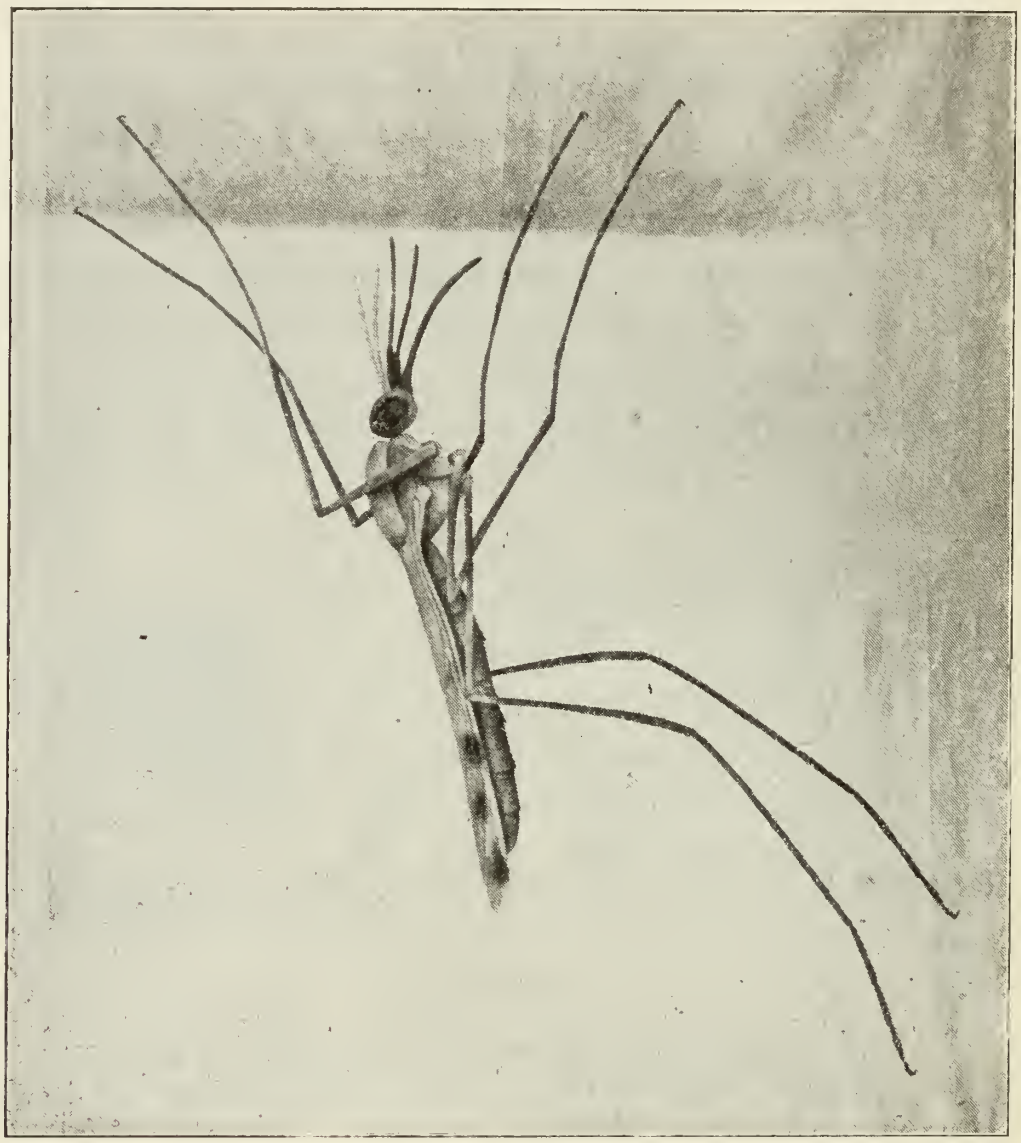


FIG. 2. Anopheles.

MOSQUITOES AND DISEASE.

It is now a well-established fact that several species of mosquitoes are the active disseminating agents of at least two or three kinds of contagious disease. Space here will not permit of the many interesting facts, or the conclusive proof by experimentation that has resulted from investigations carried on along this line in recent years; but readers who are interested in more than a mere statement of facts are referred to special articles dealing with insects in their connection with disease.

Malaria and Mosquitoes.—The old theory that malaria was caused by miasma or swampy air has now given way to the more modern and experimentally proved fact that mosquitoes belonging to the particular genus *Anopheles* are responsible for the spread of this disease. The *Anopheles* mosquito detains the malarial protozoan from the blood of a malarial patient, which, after going through a course of development within the body of the mosquito, is ready to be transferred to the blood of the next person bitten by the mosquito.

This genus of mosquitoes should be known by every one, and Figs.

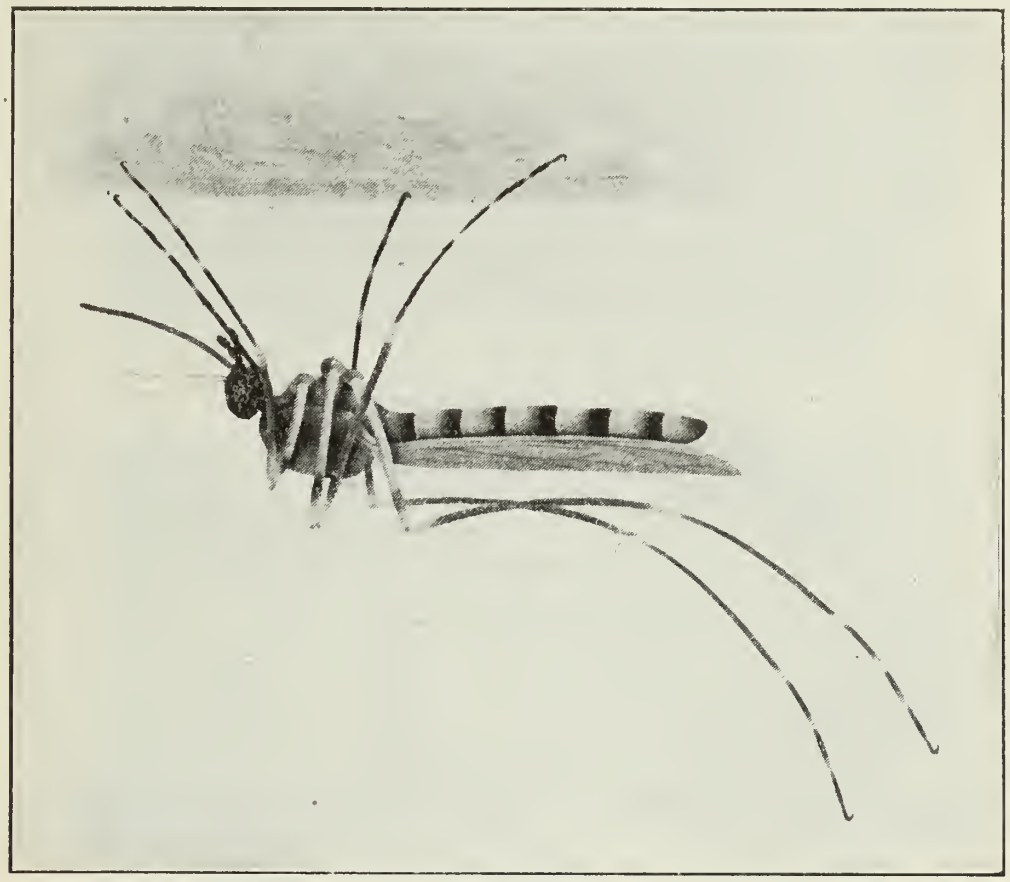


FIG. 3. Theobaldia.

2 and 3 should make this distinction clear. The *Anopheles,* it will be seen, has spotted wings, but this is not a character peculiar to the genus, since the commonest species of *Theobaldia,* here figured from the bay region of California, has spotted wings. The three appendages projecting from the head of *Anopheles* are entirely characteristic, while in the *Culicinae* there appears to be but one long process, the beak. These, which occur on either side of the beak in *Anopheles,* are the palpi, and are always as long as the beak, but in the *Culicinae* they are short and inconspicuous in the females. The males are distinguished by their bushy antennæ, but since these do no biting, it is important to know only the distinguishing characters of the females, as shown in the figures. The figures also show the characteristic resting positions of the two genera.

In Figs. 4 and 5 the normal position of the larva of a *Culicinae* and *Anopheles* is shown—*Theobaldia* with its long breathing tube and hang-

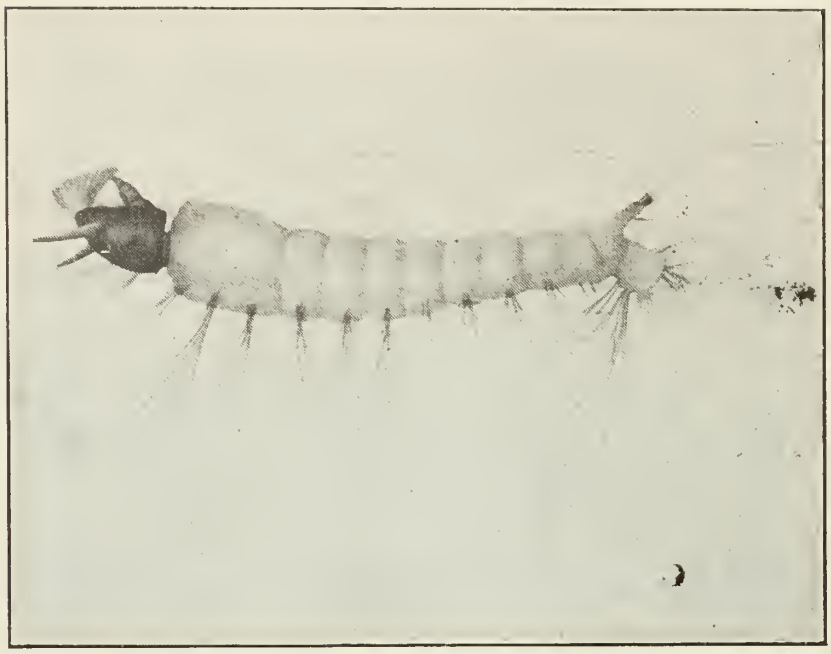


FIG. 4. Anopheles larva.

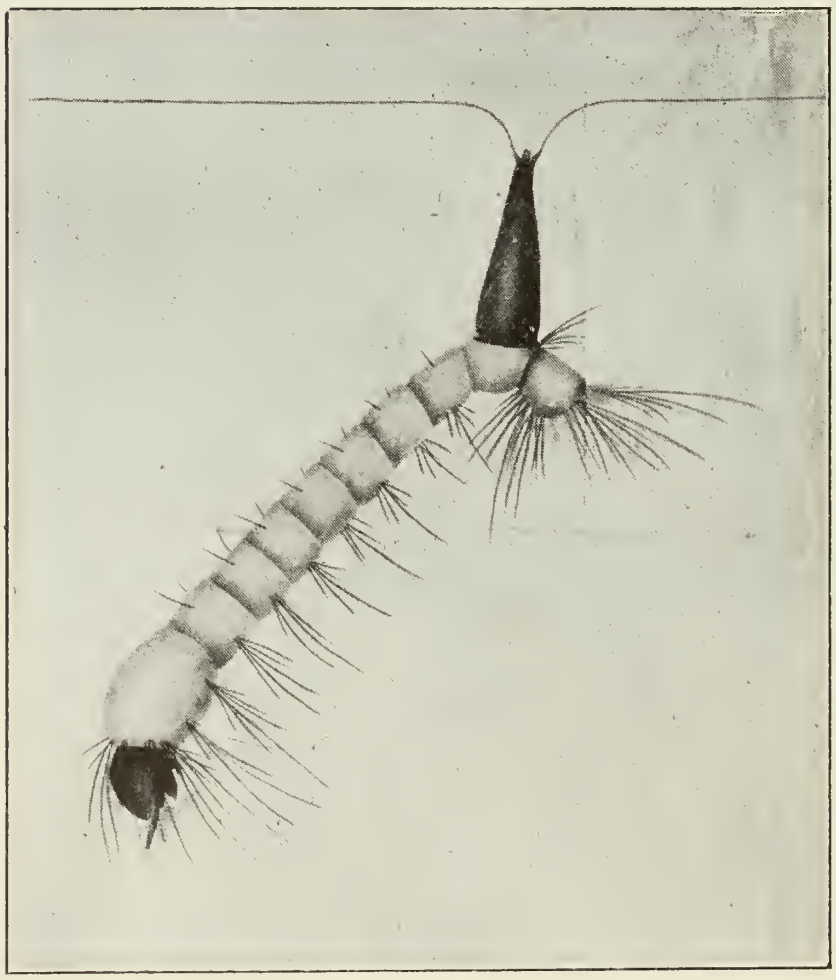


FIG. 5. Theobaldia larva.

ing at an angle, while the *Anopheles* has a short breathing tube and is parallel with the surface of the water, and is a surface feeder, while the *Culicinae* obtains its food from beneath the surface.

There are three species of *Anopheles* in California, but only one, *Anopheles maculipennis*, has been actually demonstrated to transmit the malaria protozoan. The other species, however, are likely to do so, and until they are proven incapable of acting as a host for the parasite they should be regarded with some respect.

Mosquitoes and Filariasis.—The dreaded and incurable disease known as filariasis, which is confined mostly to the tropics, is now known to be transmitted from one patient to another by mosquitoes. This disease manifests itself in several forms; one of the most common, known as elephantiasis, attacks as many as a third of the natives in some of the tropical countries, and invariably proves fatal.

Mosquitoes and Yellow Fever.—Yellow fever was, up to the last few years, thought to be spread by fomites or contact with clothing or other

FIG. 6. Pupa of a mosquito (*Theobaldia*).

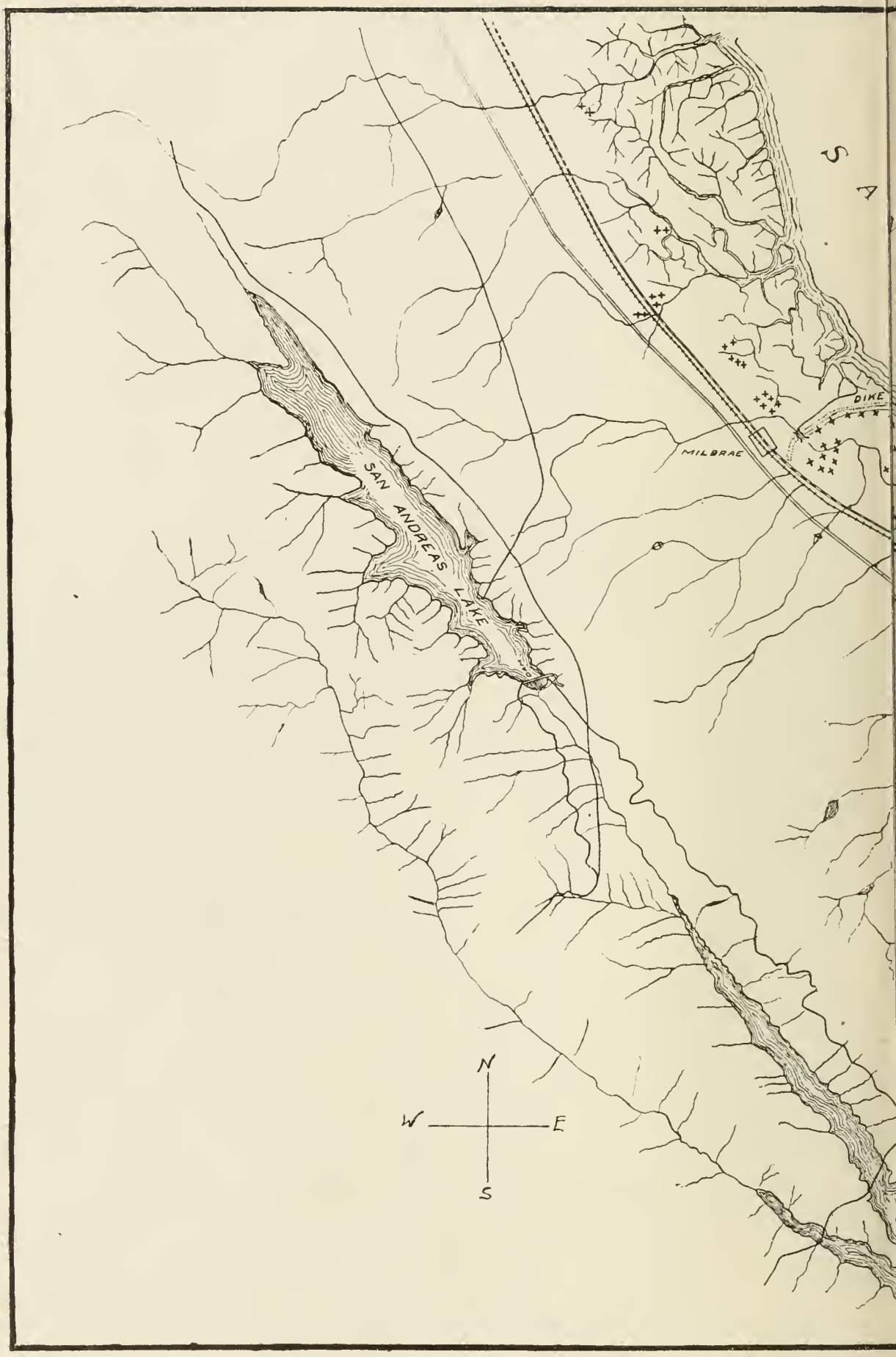
belongings of fever patients; but the investigations of our United States army surgeons in Cuba in 1900 overthrew this conception regarding the spread of the disease, and proved by actual experiment that the disease was transmitted by a certain species of mosquito (*Stegomyia fasciata*). As a result of this knowledge the disease has been practically stamped out of many places where it was formerly prevalent, among which may be mentioned Havana, in Cuba, where it is no longer dreaded in the degree that it was formerly.

Still more recent history has been made in New Orleans during the past summer, and while there were a good many deaths, the disease did not spread or cause the alarm that former epidemics have occasioned, for the reason that the etiology of the disease was better understood. According to statistics compiled by Dr. J. H. White, of the United States Public Health and Marine Hospital Service, the total number of known deaths in the entire South up to October 15th

was 924. When it is understood that there was a total of 616 dead and prostrated victims (according to the *Interstate Medical Journal*) by the time the work of eradication was well under way, the results are remarkable. In a letter just received from Dr. L. O. Howard, of the Department at Washington, he has assured us that all of the preventive work carried on there by the State and city authorities and of the United States Public Health and Marine Hospital Service was directed solely against the yellow-fever mosquito. The work included the screening of tanks, treating the gutters with oil, and other measures looking toward the abolition of the breeding places; the fumigation of houses containing fever patients in order to destroy the adult mosquito, and the protection of patients by netting in order that the mosquito should have no opportunity to bite and later convey the disease.

THE PRESENT CAMPAIGN.

The Territory.—The territory involved in the present campaign is included in the upper portion of the San Francisco peninsula, extending from South San Francisco on the north to San Mateo on the south, a distance of about 10 miles. The average width of the peninsula here is 10 or 15 miles. Extending midway between ocean and bay are two parallel chains of hills, the one on the bay side averaging 500 or 600 feet above the sea, while the chain on the ocean side attains a height of 2,000 feet at the south and gradually decreases toward the north to 100 or 200 feet. The streams rising in these hills flow rapidly, either into the bay or ocean, or into the chain of lakes which has been made artificially between the hills, and is the source of San Francisco's water supply. Beginning near South San Francisco, on the bay side, and extending well across the peninsula, about parallel with the other chains, is a ridge of 1,000 to 1,300 feet, which is known as the San Bruno Mountains. This, together with the other two ridges (see map), incloses a low area or depression not more than 200 feet in elevation, and it is through this draw that many of the winds come from the ocean, and are diverted by the San Bruno Mountains toward the southward along the bay shore. In addition to this the winds entering the Golden Gate are spread to the north and south along the bay, and it is from these two sources that most of the winds of the territory find their way from the ocean. Because of this prevailing direction of the wind, the troublesome area on the marshes will lie largely to the northward of a mosquito-infested district. It was on this basis of winds that we came to the conclusion in the present campaign that the control work should be done from San Mateo northward, and little attention paid to the territory to the south; and the results have fully confirmed this conclusion.



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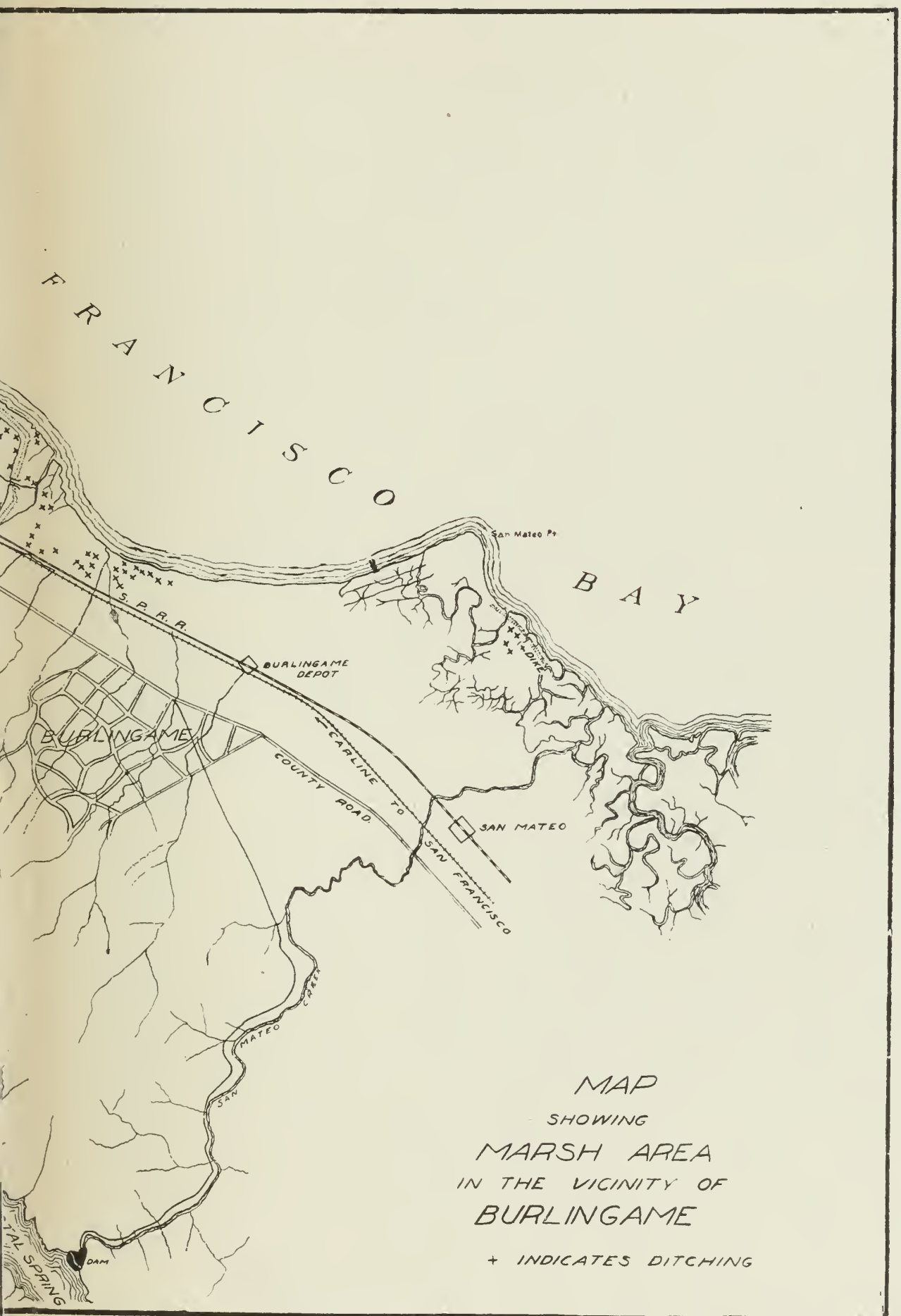
FRANCISCO
BAY
San Mateo Pt
S. P. R. R.
BURLINGAME DEPOT
BURLINGAME
CARLINE TO SAN FRANCISCO
COUNTY ROAD
SAN MATEO
MATEO
SAN
DAM
MAP
SHOWING
MARSH AREA
IN THE VICINITY OF
BURLINGAME
+ INDICATES DITCHING

The salt-marsh area included in this campaign consists of a narrow strip along the San Francisco bay shore, varying from ½ to 2 miles in width, and 10 miles long, or from San Mateo to South San Francisco. No part of this area is continually covered with water, and it is all above the lowest high tide. The higher tides, however, particularly those accompanying full moon, almost completely submerge the area. Extending from opposite Millbrae to the south, along the bay, is a diked area of 500 or 600 acres. This dike was built about fifteen years ago, and, excepting for a year or two after completion, has been neglected, and consequently in very poor repair.

Extending over the entire marsh area is a complete network of tidal creeks, which wind about in all directions, and thus furnish a rapid drainage during low water. This fact also greatly simplifies the drainage problem, since no long ditches need be cut. The vegetation on the marsh land consists of the common pickleweed (*Salicornia ambigua*), which is the characteristic plant, and the finer salt-grass (*Distichlis spicata*), which borders the pools and tidal creeks. There are no tules or large rushes on this marsh, since there is no part of it that is more or less continuously submerged with water.

What Was Done on the Marsh.—The actual work of control was commenced February 27th, when a gang of men was started to work at ditching on the salt marsh. This work was started near the Blackhawk dairy, where the marshes begin north of Burlingame, it being the intention to work northward toward San Bruno, and make the work permanent as far as we would be able to go in a single season. However, the work went rapidly and the troublesome areas north of Millbrae were not so numerous as was figured, and consequently practically the whole area was covered during the past season.

The ditching in the Blackhawk area consisted in connecting the pools and areas of standing water with the tidal creeks in order that they might drain more rapidly and before a brood of mosquitoes would have time to develop. The largest of these ditches were 12 inches wide and about 15 inches deep, and these served as main channels into which smaller laterals were cut. These laterals, and, indeed, the greater part of all of the ditches, were but one spade wide, and one or two spades deep, according to the depth of the pool to be drained. Only where the pools were very large and a great quantity of water to run off in a short time was it necessary to make larger ditches. By "a spade" here is meant the common California spade, which is about 6 inches wide and 10 inches high. The Eastern drain spade has not yet found its way to California; undoubtedly it would be preferable for the deeper ditches in this kind of work. In addition to the well-defined pools there was a considerable area in the Blackhawk region which

FIG. 9. One of the main laterals, into which were cut smaller ditches.

FIG. 10. A large tidal creek in the diked area, almost dry.

was covered with but a few inches of water for a considerable time after each high tide, and before the rains ceased in the spring water stood over this area almost continuously. Such areas had to be treated by making a number of parallel ditches from 50 to 75 feet apart, in order to permit of sufficiently rapid drainage. Rather extensive ditching was done here to make the area safe while the rains were still continuing, while later in the season, when the rains ceased, it would have

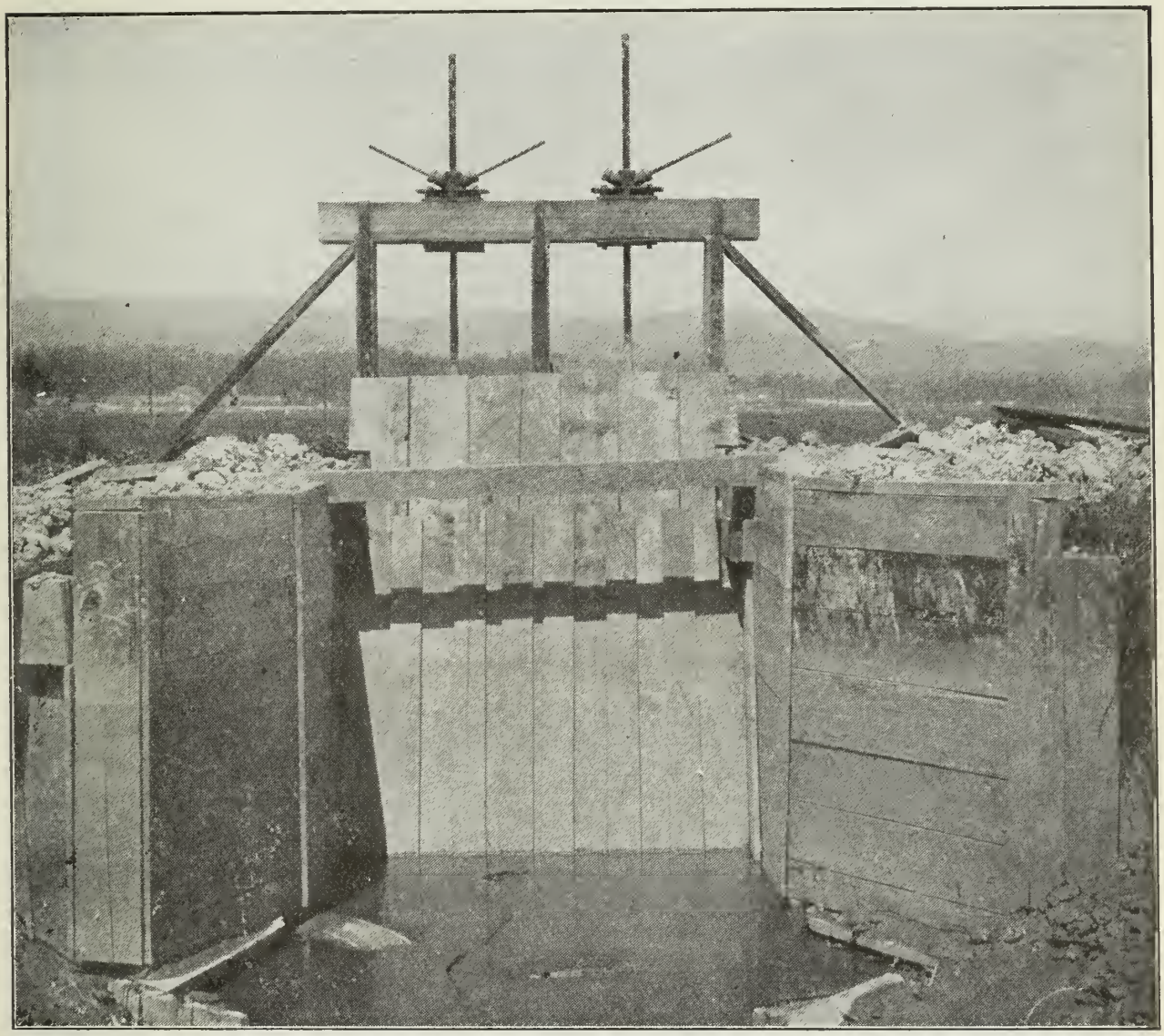

FIG 11. The lower gate on the dike, showing automatic gate in front of old one manipulated by screws.

been safe with much less ditching. Small pools that were far from tidal creeks were made safe by filling in rather than draining. The size of the pool, and the length of ditch necessary to drain, will determine which of the methods is to be followed. In this way the marsh area was gone over, doing away with all the places where larvæ were found or were likely to be found, for a distance of about a mile along the bay northward, where the diked area was met with.

This part of the marsh presented a more difficult problem. The

dike, having been neglected for ten or twelve years, was in poor condition, and there were several breaks in the upper end near Millbrae. The gates were not in working order, and their floors were too high to drain the area inclosed.

The breaks in the dike at the upper end permitted the water to back up at the opposite side, and this, together with the fresh water from the hills, kept the water level, at almost high tide, over a large part of the area. To make matters worse, the dike, just after it was built, was in effective operation just long enough to thoroughly dry the ground and cause it to crack. These creeks, which are 4 or 5 inches wide and 2 or 3 feet deep, still exist, forming a complete network over most of the area. Mosquitoes were found breeding in this area, and it was next to impossible to get over the ground, even with waders. A considerable part of the area was submerged to the depth of a foot or more, thus concealing from view the cracks and tidal creeks, which one was likely to fall into at any step, and which made any attempt at rapid progress somewhat discouraging.

It was at once evident, under these conditions, that if the area was to be controlled, the dike must be either cut through in a number of places in order to allow a freer circulation of water, or the breaks must be repaired and the gates put in operation, and the water kept out. The latter scheme was the one followed, because it would be possible to make the area thoroughly dry, and thus the results would be more certain. In attempting to operate the gates we were made to appreciate the effect of a ten or twelve years' coating of rust on the large screws by which the gates were manipulated. After the gates were put in operation the breaks in the dike were repaired and the weak places strengthened. The largest break repaired was immediately joining the upper gate. This was 30 feet wide, and by the action of the water had worn down so that at high tide there was a depth of 10 feet of water. A double wall of sheet piling about 6 feet apart was sunk here and the space between filled in with earth. The other breaks were repaired by sinking a single wall of sheet piling in the center and filling in on both sides with dirt.

After these repairs were completed the gates were operated, opened at low tide and closed at high tide, for a week, but at the end of this time there was still much water in the area, because the gate floors were not low enough to lower the water level sufficiently. This made it necessary to lower the gate floors and add an extension to the gates to reach the lower level. This being done the gates were again operated for several days, but it was found that, due to seepage of water through the dike in many places, hand operating would have to be kept up almost indefinitely. It was, therefore, necessary to replace these old-

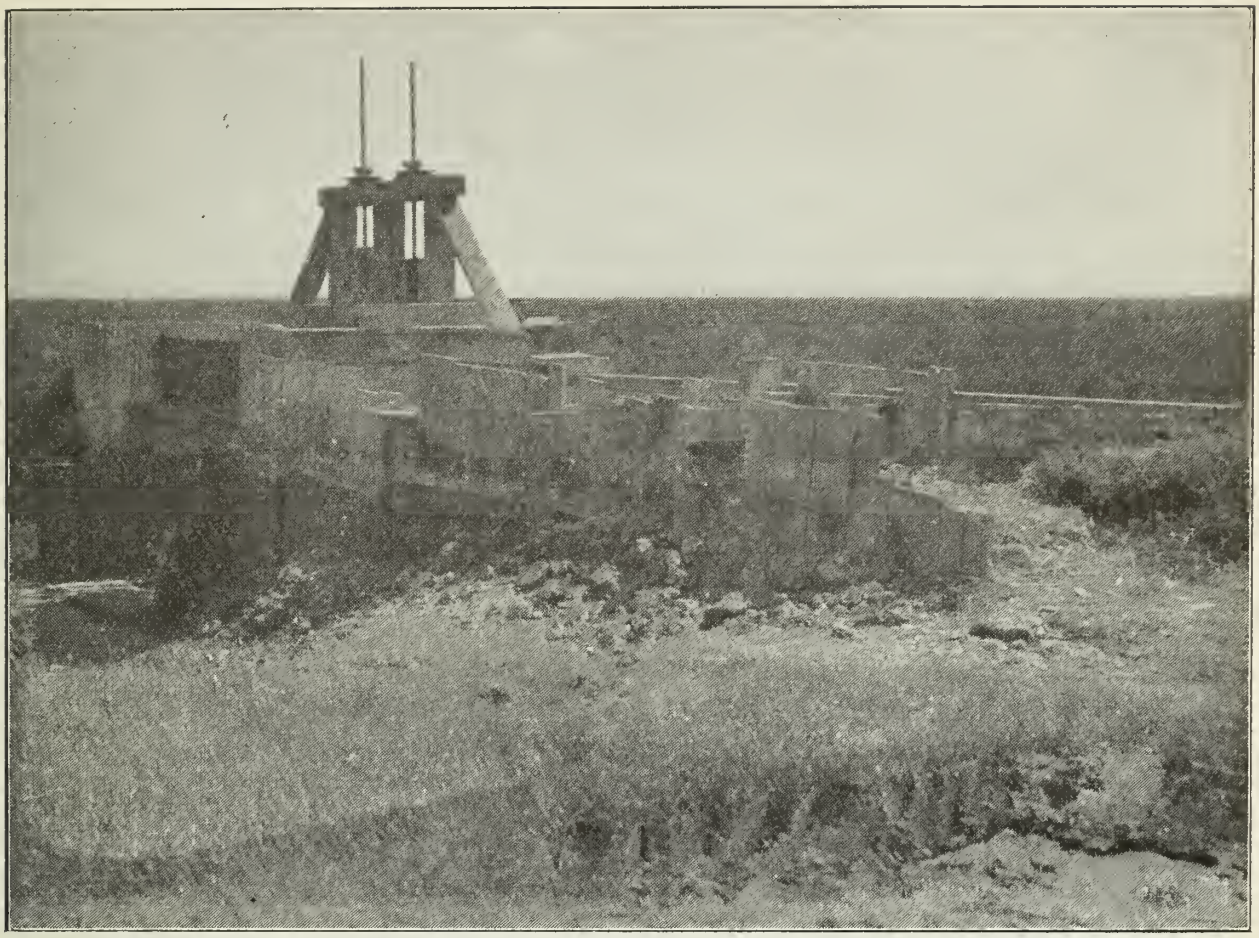

FIG 12. Upper gate on dike. On right, double wall of sheet piling shows manner of repairing large breaks.

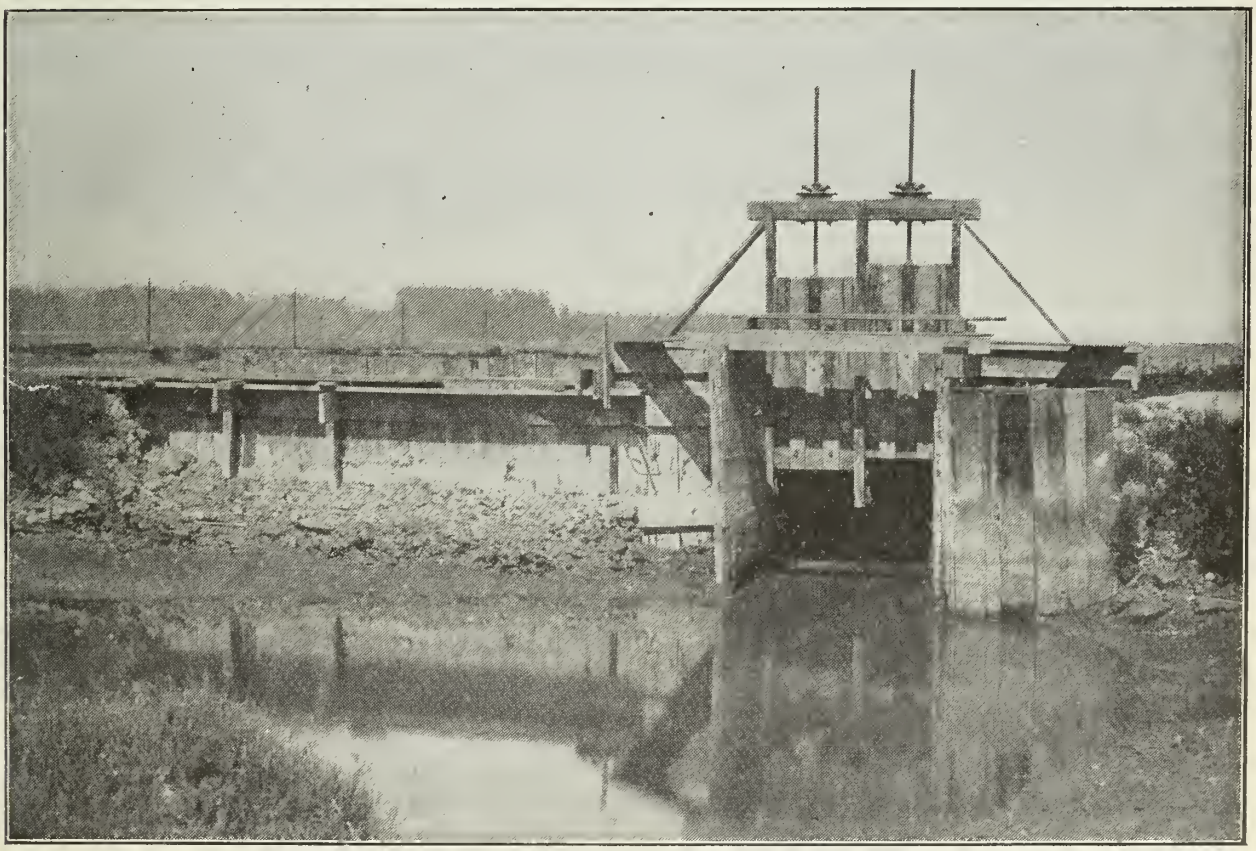

FIG. 13. Upper gate on the dike. Beam in center shows former level of floor. Repair work on left.

style gates, operated by hand, by automatic ones, and these were, consequently, put in at both the upper and lower gates, and the floors lowered 32 and 20 inches respectively. These gates were made to swing on an axle at the top, the lower end being free and easily moved by the pressure of the water, so that at low tide it was opened by the pressure of water on the inside, and closed as the water from the high tide rose on the outside.

The tidal creek which served as an outlet for the lower gate had become filled in to a depth of 2 or 3 feet during the period the gate was closed, and this was cleaned out for 300 or 400 yards toward the bay in order to drain out the area inclosed by the dike.

FIG. 14. A typical hand-made ditch on the marsh.

With this work done upon the dike the area inclosed by it was treated in much the same way as that outside, except that the network of cracks, already mentioned, had to be filled in in many places, and several of the tidal creeks deepened. The reward for all this work came later in the season when the area was changed from a veritable breeding ground to the safest portion of the marsh. Indeed, this area was the key to the situation, and the excessive abundance of mosquitoes in this particular territory was without doubt due to this extensive breeding ground.

It is appropriate to mention here the connection of this work with the reclamation of marsh lands. This tract of 500 or 600 acres, which had been useful only for duck-hunting, is now thoroughly dry and could be put to agricultural uses at very little additional expense. Such

work has already been extensively taken up on the marshes below San Mateo, and it has been found that a good crop of grain can be raised on such land in the second year of its cultivation. It is safe to predict that all the marsh land involved in the present campaign will be under cultivation before many years, and because of its proximity to the metropolis of the coast should be very valuable.

Besides the marshes already mentioned, permanent control work was done on the marsh about Millbrae and northward to San Bruno, and also some drainage work at Coyote Point, opposite San Mateo. The work at these places was much the same as that already described, and further details are unnecessary.

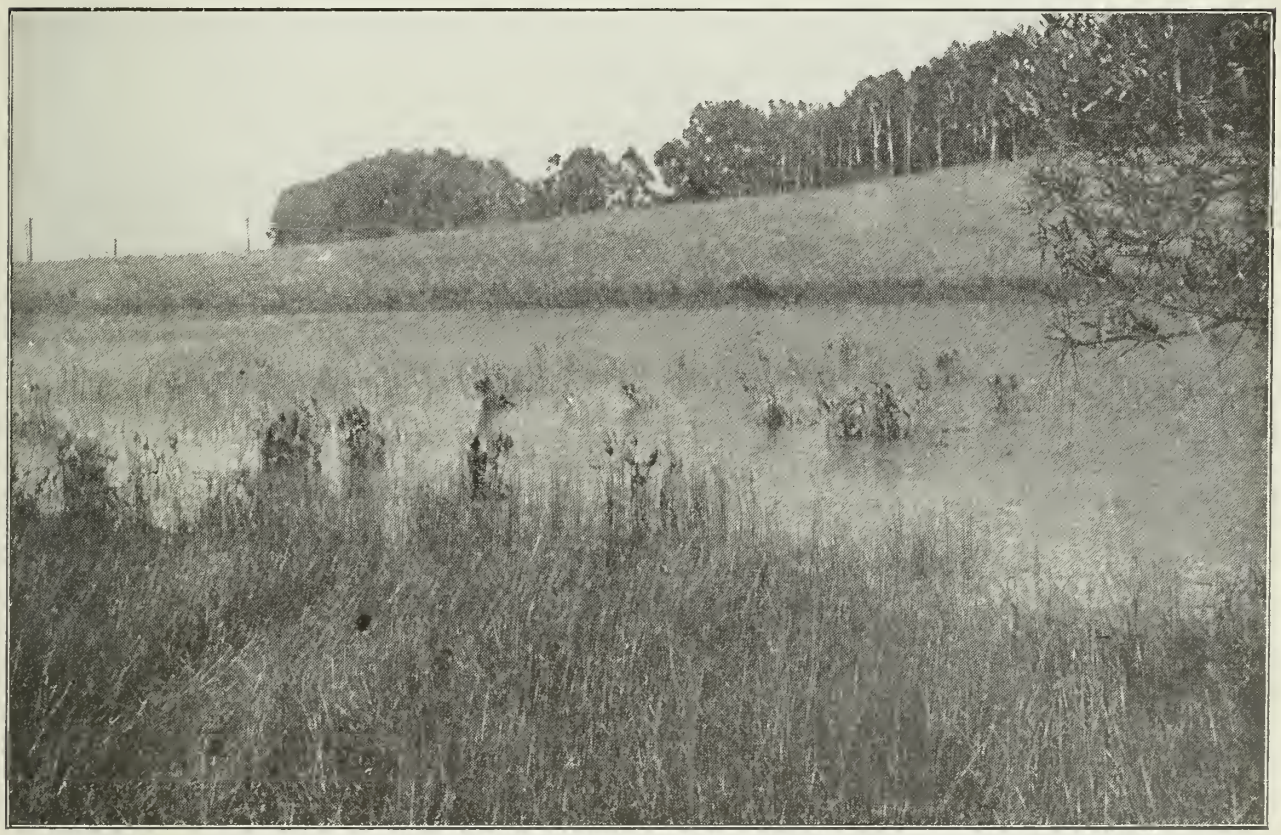

FIG. 15. A large fresh-water pond. A favorite place for *Anopheles*.

In addition to this permanent work there was some oiling done on the marsh where the ditching and filling work were not rapid enough to keep ahead of a developing brood. The total amount of oil applied, however, did not exceed 400 gallons, and most of this was applied to the large tidal creeks in the reclaimed land opposite San Mateo. The remainder was applied to pools where wrigglers appeared after a high tide, and, the brood being checked, we had until the next high tide in which to make the pools permanently safe.

The Fresh-Water Problem.—The fresh-water problem is a comparatively easy one in this section, because of the good drainage toward the bay, and because of the cessation of rains in the early spring. Pools and creeks that once become dry require no further attention during

the season, and this greatly simplifies control work against fresh-water forms in arid climates like that of California. The most troublesome breeding places for fresh-water mosquitoes in the Burlingame section are in the numerous creeks coming down from the hills. Some of these dry up very soon after the rains cease, but in others there may be standing pools until late in the summer. These pools are due generally to seepage which may make its appearance at different places along the course of the creek.

During the present season most of these creeks were oiled and a few were drained. Where the creeks soon become dry one application of oil may be sufficient, and this is almost as satisfactory as draining, since, owing to the heavy rains of winter, and the swift current, débris is lodged in some places and holes made in others, so that the creeks must be gone over every season. Moreover, many of the creek beds

FIG. 16. Same pond after drainage. Outlet in background.

along a part of their course are in solid rock, which makes draining difficult. However, in spite of these objections, the experience this year would warrant drainage, especially in the creeks where the water remains in pools and pockets for several months after the winter rains.

In addition to the creeks already mentioned there are a few fresh-water ponds in the territory, but the worst one of these has been drained. This pond was on the Easton property, half a mile north of the Burlingame depot, and was a favorite breeding place for the malarial mosquito (*Anopheles maculipennis*). The owner of the property drained this pond at his own expense, which not only made useful a tract that was formerly a waste, but also added to the value of the land in the immediate vicinity, which has since been subdivided into residence property, to say nothing about the riddance of the malarial and other mosquitoes. The ditch draining this pond was made with

FIG. 17. Cutting the ditch for drainage of Easton pond.

FIG. 18. Cutting the ditch for drainage of Easton pond.

horses and scrapers, and is 12 feet wide at the top, 4 feet at the bottom, and from 3 to 5 feet deep.

A considerable amount of oiling was done on the fresh-water areas, the permanent work having been pretty largely restricted to the marsh lands. The oil used was a combination of heavy oil of 18 degrees gravity and light oil of 34 degrees gravity, in the proportion of four to one. This mixture made an oil that was just thin enough to spray well from an ordinary spray nozzle, and yet was thick enough to withstand very rapid evaporation. It was applied by means of a barrel

FIG. 19. The ditch after it was completed.

pump, where this could be used, but in the creeks and other situations which could not be reached by horse and wagon, the ordinary knapsack pump was used. The price of the heavy oil at Burlingame was 2 cents a gallon, while the lighter oil was 2½ cents a gallon. The former was obtained from the Bakersfield district, while the latter was a product of the Coalinga fields. The number of applications of oil depended somewhat upon the nature of the pool and its exposure to winds, but in no case could it be counted as thoroughly effective after a period of four weeks.

Suggestions for Future Work.—It is, of course, impossible to cover all of the ground completely in a single season, and while no breeding place on the marsh escaped us this year, new ones are likely to appear in the future, so that the territory should be gone over for two or three years, or until every possible breeding place is rendered safe. The large tidal creeks opposite San Mateo harbored mosquito larvæ during

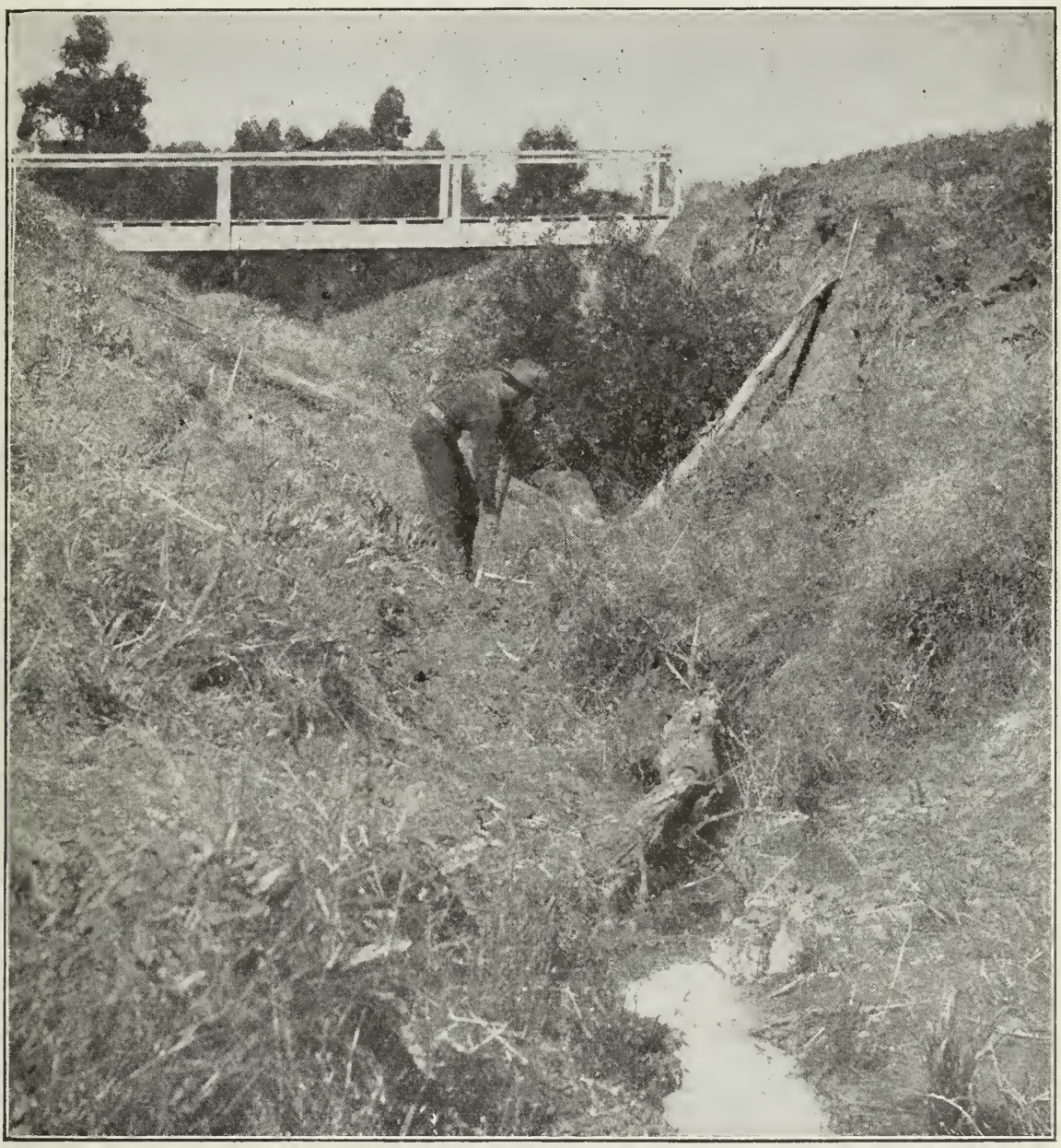

FIG. 20. Draining in one of the typical fresh-water creeks of Burlingame.

the past season, and are likely to give trouble again next year. Mosquitoes from this breeding ground, however, may not get as far north as Burlingame, but they will certainly reach San Mateo, which is just opposite. There is also a small creek running alongside the road at the Burlingame wharf that should be attended to during the coming season. This was oiled during the past summer, but it is troublesome up to July, and should be drained by putting a culvert through the road to the bay. In this culvert should be built a self-operating gate, which

will allow the water of the ditch to pass out, but prevent the high tide from entering again. The gates on the dike should be visited occasionally to see that they are in working order, and are not kept from closing by timbers which are likely at any time to drift in and lodge in the gate. The dike should also be inspected for breaks or weak places, particularly at the upper end opposite Millbrae.

On the fresh-water area all standing pools which are formed by the late spring rains should receive attention by either oiling or draining. It is recommended that the least amount of oil that must be used the better, and that all the work should be permanent, where it is at all possible, and this includes practically everything. The creeks should be attended to immediately after the rains cease and drained by either cleaning out the creek bed or filling in the holes, or both. Lastly, every one should look to his own immediate premises and see that such containers of water as horse-troughs, fountains, pails, or tin cans are not furnishing mosquitoes for the neighborhood. In a city, or thickly settled residence country such as Burlingame, community effort is essential.

Fish vs. Mosquitoes.—A part of the plan of the present campaign included the carrying out of some large-scale experiments on the use of fish as a means of keeping the salt-marsh mosquito in check. However, when the typical breeding place of this mosquito was well understood, the idea was soon abandoned as impracticable. Where there were no permanent pools, which were necessary for the maintenance of the fish, there were no mosquitoes; whether this was due entirely to the fish we are not yet ready to answer. So far as our present experience goes the salt-marsh mosquito (*Ochlerotatus lativittatus*) prefers mud to water in which to lay its eggs, and it is possible that the eggs would not be laid in these permanent pools where fish are present. Whether the eggs are laid here by preference of situation or through instinct in keeping away from the fish is a question difficult to answer, but the fact remains that it is the exception that mosquitoes are found in the salt-water pools where fish are present.

But this is not all of the question. Practically all of the salt-marsh mosquito larvæ in the present campaign were in situations which were unsuitable for fish, situations where fish would perish in a very short time were they introduced. These situations are the pools that depend entirely for their existence upon the monthly high tide, and which dry up in from a week to three weeks thereafter. In order for fish to be effective here they would have to be introduced after every high tide, an operation which would be, obviously, impracticable. Fish are considered by zoölogists as being a rather successful group in the struggle for existence, and favorable situations for their development will usually

FIG. 21. The oiling outfit.

FIG. 22. Oiling in the creeks.

be found stocked with them. And so in the present territory all permanent pools were pretty well stocked with fish. Of course this does not preclude the feasibility of introducing carnivorous species in territories where they are not now predominant, or where the species are less carnivorous, or wholly vegetable-feeders. But even in ponds that may contain an abundance of fish in the freer water of the middle, the vegetable tangle of the borders may be pretty well stocked with larvæ, where they breed undisturbed by most fish.

In a letter under date of October 9th from President Jordan, of Stanford University, he states that the only fish likely to destroy mos-

FIG. 23. Making a ditch for diverting water, which formerly spread over a wide area, to a definite channel.

quito larvæ to any extent in the San Francisco Bay region, would be the stickleback (*Gasterosteus cataphractus*). We have found this species in the permanent clear-water pools mentioned above, and it may be effective in keeping the mosquitoes down here; but this fish, like all the others, does not reach the pools where the mosquitoes really are; that is, the temporary pools and areas formed by the higher tides. In reservoirs, or fresh-water ponds artificially formed, or in fountains and the like, or in the introduction of carnivorous forms in permanent pools where they are not now present, fish must be considered as a factor in mosquito control; but the mass of mosquito breeding-places are beyond the limits of the typical environment for fish.

Other Natural Enemies.—Besides fish there are several species of insect relatives that prey upon the mosquito in both its aquatic and adult life, and which are, to some degree, effective in keeping the numbers within reasonable limits.

The larvæ of dragonflies are carnivorous in habits and feed upon the mosquito larvæ to some extent, but, like most of the other natural enemies, they have been given all the credit, and probably more than they deserve. We have found mosquito larvæ common where there was an abundance of dragonfly larvæ in the pond, but in such situations larvæ were never seen to be fairly swarming, as they were in smaller pools that were free from enemies of all kinds. Where dragonfly larvæ occur it is not unusual to also find fish, since dragonflies require the greater part of the year, or more, to go through their development, and hence require more or less permanent pools.

The larvæ of the predaceous diving beetles (*Dytiscidae*) were also found in places where water exists, at least for the greater part of the year. These larvæ are voracious eaters and are more active than the sluggish dragonfly larvæ, which prefer the mud or slime of the pond bottom, and are no doubt more effective, individually, than the latter; but in this territory they were never found to occur in large numbers. Bodies of water that are favorable, therefore, for the development of one kind of enemy usually harbor a variety of enemies, and all of these taken together are effective in keeping the numbers of mosquito larvæ from becoming excessive.

There are several species of water bugs, including the water boatman (*Corisidae*), water striders (*Gerridae*), backswimmers (*Notonectidae*), and water scorpions (*Nepidae*), that prey upon mosquito larvæ, and these may be found in less permanent pools than those already discussed. A species of water boatman (*Corisa*) occurred in immense numbers in some of the more permanent pools of the salt marsh, and in these pools no mosquitoes were present. But there are too many conditions entering in to ascribe the absence of mosquitoes to this particular bug. In several fresh-water pools where the water strider was abundant, mosquito larvæ were seen in great numbers, and these water bugs seemed to have no effect on the number of larvæ. Of course, there was enough difference in the numbers to make the supply of food far beyond the demands of the enemy, but this too often occurs with the slower-developing predaceous enemies of the mosquito.

In general, in the present territory, the typical breeding places for the mosquito are not the typical breeding places for most of its enemies. The mosquito being more prolific and the number of broods so much greater than most of its enemies, it persists in spite of them, and, moreover, its distribution extends beyond the limits of most of its enemies, which are restricted to more permanent breeding places.

Bluestone as a Mosquitocide.—A number of experiments were carried on to test the value of copper sulfate for the destruction of mosquitc larvæ, but, since the results were essentially the same as those already given in detail in Prof. Smith's New Jersey report and also described by Marlatt in *Science* for April 21, 1905, only the general conclusions suggested by the experiments will be given here.

The value of bluestone as an insecticide depends largely upon its power of destroying the small organisms, particularly algæ, in the water and thus depriving the larvæ of food. . Obviously, this will be of little use against pupæ or nearly full-grown larvæ, and in our experiments these invariably developed into adults. Some large-scale experiments were carried on in the field, but these proved more unsatisfactory than those carried on in the laboratory. For example, a cattle-guard on the railroad at Millbrae was fairly swarming with larvæ and pupæ of *incidens,* and copper sulfate was used at the rate of 1 to 1,000, much beyond the practicable strength, yet adults continued to emerge in great numbers. Indeed, there was no effect observed excepting that a few of the younger larvæ were killed. The water here was, to be sure, very foul and the case was an extreme one, but in other clearer pools the results were almost as unsatisfactory. Since in the present campaign it was our business to keep down the mosquitoes, we could not afford to prolong these negative field tests; but if copper sulfate is to be used at all it should be applied very soon after the eggs hatch, since it is too slow acting to be of value against the later aquatic stages. Its use is no doubt limited to reservoirs or small bodies of clean water where it will not be precipitated so rapidly.

Eucalyptus vs. Mosquitoes.—It is recorded in some books, and we have heard it stated on two or three different occasions during the past year by physicians, in lecturing on mosquitoes and disease, that the eucalyptus tree is effective as a repellant, and that where these trees exist no mosquitoes will be found. In the Burlingame section all of the numerous winding avenues are lined with eucalyptus; there are eucalyptus along the highways, and there are groves of eucalyptus; yet, where these trees are most abundant it might be said that the mosquitoes are most numerous. It was here that the first shipload of cuttings, imported from Australia, were planted, and the eucalyptus tree is the predominant cultivated tree of the territory.

During the summer of 1904 we captured in five minutes' sweeping, immediately under eucalyptus trees, a pint cup full of mosquitoes! Coyote Point, on the bay shore, has long been known by the residents in the neighborhood as a famous place for mosquitoes; indeed, the construction of a hotel at this point which has been under contemplation for some time is said to have been abandoned because of the abundance

of mosquitoes, yet this point is covered with eucalyptus trees. It should not be understood from what has been stated that the eucalyptus tree attracts mosquitoes. It does this only in so far as it affords shelter, and other trees will do this as well, indeed much better, as for example the Monterey cypress with its denser foliage, which is so common in this section. So far as the experience in this locality is worth anything, people need not entertain very high hopes of the mosquito pest disappearing through the planting of the eucalyptus tree.

LEGISLATION.

The citizens of the city of San Mateo had been active for some years in fighting the mosquito, but because of a lack of knowledge of the situation, no very effective work was done. The fresh-water areas were pretty well attended to, but mosquitoes were still present, and these, as we observed during the season of 1904, were of the salt-marsh variety. The fact that mosquitoes breeding on the salt marsh migrate a considerable distance was not generally known among the people of San Mateo, as is the case in most communities, unless they have kept in close touch with the progress of mosquito-control work. During the past year quite effective work was done, through voluntary subscription, in keeping in check the fresh-water species in the immediate vicinity. And this, together with the work done by the Burlingame people, kept the city quite free from mosquitoes during the past summer.

In order to make this work permanent, and, incidentally, to have some check upon the obstreperous person who is still living in some past age regarding his and his neighbor's welfare, the following law was passed; first by the trustees of the city of San Mateo, and later by the board of supervisors of the county.

The following is a copy of that law:

ORDINANCE No. 106.

AN ORDINANCE FORBIDDING THE MAINTENANCE OF ALL PLACES BREEDING MOSQUITOES, DECLARING SUCH PLACE A NUISANCE AND PROVIDING A PENALTY FOR THE VIOLATION OF THE ORDINANCE.

The Board of Trustees of the City of San Mateo do ordain as follows:

SECTION 1. All pools of water, or other places in which mosquitoes are being bred, are hereby declared to be a public nuisance. The Board of Health of San Mateo is hereby given authority, and it is made its duty, upon the complaint, in writing, of any resident of said city, to condemn as nuisances, any such pools of water or other places in which mosquitoes are being bred, and order the summary abatement thereof.

SEC. 2. Upon being notified by such Board of Health, of the existence of such pools of water or other places in which mosquitoes are bred, and that the same has been declared a public nuisance by said Board of Health, it shall be the duty of the person or persons responsible for the maintenance thereof, to forthwith abate such nuisance, and all persons refusing or neglecting to forthwith abate such nuisances

as directed by said Board of Health, shall be deemed guilty of misdemeanor, and upon conviction thereof shall be fined not more than fifty (50) dollars, or to be imprisoned in the county jail not more than twenty-five (25) days, or by both such fine and imprisonment.

SEC. 3. This ordinance shall take effect and be in force from and after fifteen days after its passage.

Introduced the 24th day of July, 1905.

Passed and adopted as an ordinance of the city of San Mateo, this 17th day of July, 1905, by the following vote:

Ayes, and in favor of the passage of said ordinance—Trustees J. H. Hatch, Geo. A. Kertell, M. J. Powers, J. P. Weller, W. H. Brown.

Noes, and against the passage of said ordinance—None.

Absent—None.

WM. H. BROWN,
President of the Board of Trustees of the City of San Mateo.

[SEAL.] Attest: R. H. JURY,
City Clerk and ex-officio Clerk of the Board of Trustees of the City of San Mateo.

FIG. 24. Scene in the Burlingame gardens in 1904. Workmen were obliged to wear netting for protection against mosquitoes. Such apparatus was not seen in 1905.

RESULTS OF THE CAMPAIGN.

During the summer of 1904 the mosquitoes in the Burlingame district were almost intolerable. Gardeners and other workmen were obliged to wear mosquito netting for protection. In walking along the roads in the vicinity of the hills mosquitoes would gather so abundantly on one's clothes that sometimes the color of the suit was almost obscured beneath the general effect of the light brown produced by the marsh mosquito. It has been stated in another connection that on one occasion a pint measure of mosquitoes was captured in five minutes' sweeping! These were, without exception, *Ochlerotatus lativittatus* from the salt marsh.

Owing to the delay due to the extensive repairs on the dike, a brood of mosquitoes emerged from the diked area before our control work became

effective. They consisted, partly, of the brown marsh species, *Ochlerotatus lativittatus*, but mostly of the gray marsh species, *L. squamiger*. These made their way to the hills opposite their breeding ground, and *squamiger* got as far south as Burlingame and San Mateo, while *lativittatus* was limited to the territory about Millbrae. *Squamiger* was rather abundant at Burlingame during March and April, but gradually disappeared until late in June, when no more were seen during the season. An occasional *incidens* was sometimes met with, due to the fact that a few fresh-water pools escaped treatment; but their numbers were so few as to be hardly noticeable.

Regarding the brown marsh species (*Ochlerotatus lativittatus*) which were so abundant and vicious in preceding years, and against which the main work of the campaign was directed, the rather remarkable result was obtained that throughout the entire season in the Burlingame section not a single specimen was seen. This mosquito, then, was practically annihilated for a distance of 10 miles along the bay shore, and, had we been able to get on the diked area earlier, *squamiger* would undoubtedly have met a similar fate. As it was, it gave practically no trouble after May, and completely disappeared by July. It may be argued that the season or some other condition had something to do with the results. But the fact that they were abundant enough in other situations about the bay, and that this early brood gave promise of a good season for the mosquito, would indicate that the control work was the chief factor in the problem, in view of the fact that millions of larvæ were killed on the marsh.

The ultimate results of such a warfare against mosquitoes can hardly be realized. Before the campaign was well started, it had a direct influence upon the real estate of the district, and many people were induced to locate in the territory largely on the basis that the mosquito nuisance was solved. This region is essentially a country of homes, and many of the people of wealth, having their business interests in San Francisco, come here to live during the summer. They come here in order that they may live out of doors, and with hordes of hungry mosquitoes waiting to devour them, as was the case in previous years, the desirability of inaugurating a warfare against the pests can at once be appreciated.

THE SPECIES CONCERNED.

The four commonest species, and the only ones that counted very largely in the control work, were: *Ochlerotatus lativittatus, Theobaldia incidens, Culex tarsalis,* and *Lepidoplatys squamiger*. These are treated in detail in the following pages, while there is added synoptic tables for determining the adults, and a bibliography of all the species known to occur in California.

Ochlerotatus lativittatus.

Habits of the Early Stages.—The eggs of this species are laid, so far as our observations go during the past year, in the mud of pools which

FIG. 25. Claws of Mosquitoes.

1, 2, 3—First, second and third of *Culex tarsalis.*
4, 5, 6—First, second and third of *Theobaldia incidens.*
7, 8, 9—First, second and third of *Lepidoplatys squamiger.*
10, 11, 12—First, second and third of *Ochlerotatus lativittatus.*

are formed by the monthly high tide, and which dry up before the succeeding high tide reaches them. This was demonstrated several times during the season by taking mud from such pools and submerging it

with ordinary sea water, when the wrigglers would appear in from three to four days. Another method of determining this egg-laying habit consisted in sinking ordinary soap boxes, the bottoms first being removed, to a depth of two or three inches in the mud of pools where larvæ were likely to appear. These boxes were thoroughly screened on the top to prevent any possible entrance of adults, and were kept from floating away with the high tides by means of stakes driven into the ground. When the high tide reaches the pool the mud inclosed by the

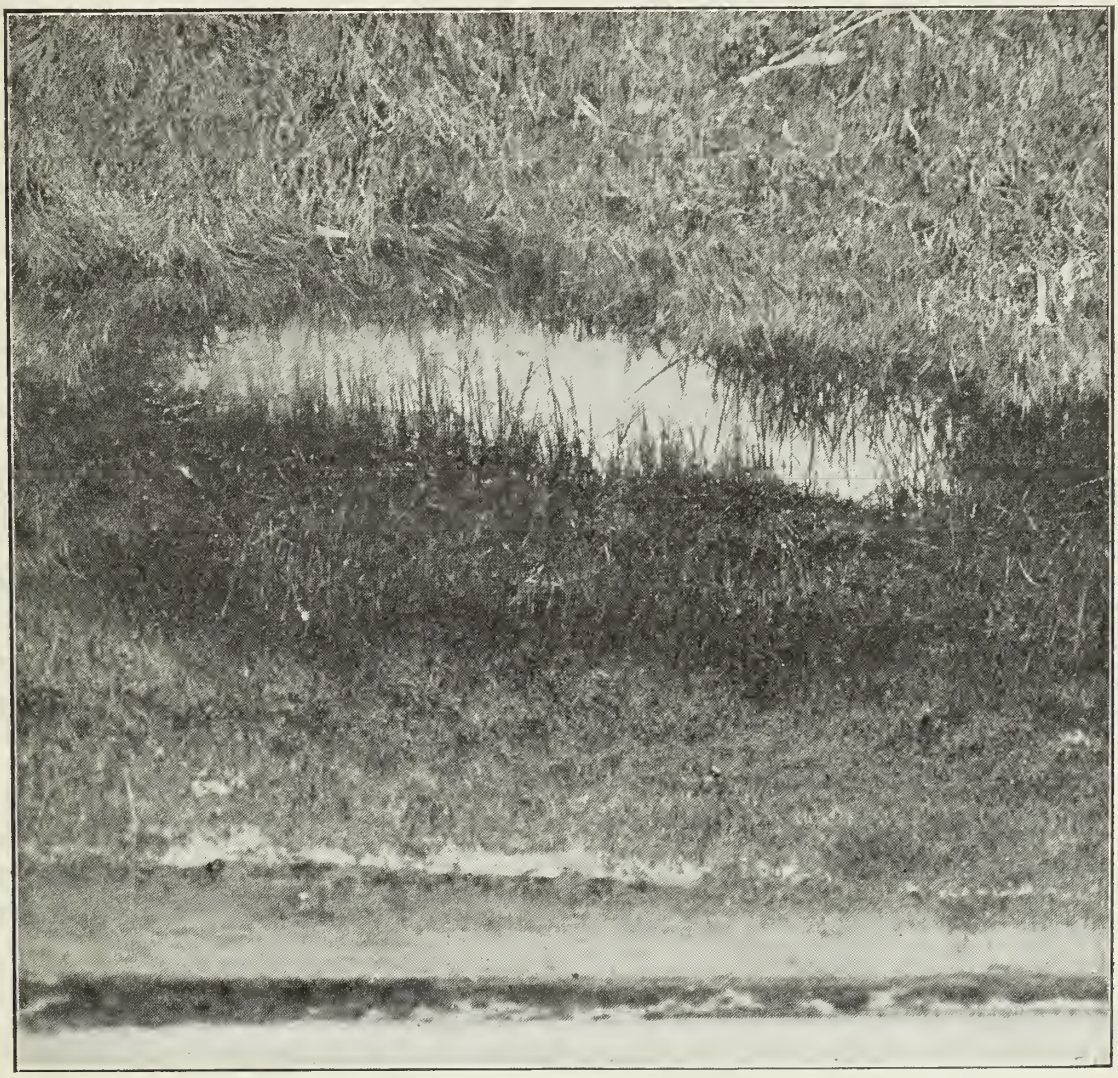

FIG. 26. A typical breeding pool on the salt marsh. Reached only by the higher tides.

box would be covered with water through seepage from below, the box being high enough to allow no water to enter at the top, thus allowing no possible chance for the eggs to be deposited in the water. In a few days larvæ would appear in the box in as great numbers proportionally as in the pool outside the box. This egg-laying habit was further verified by the fact that throughout the season there were no instances recorded where larvæ appeared in permanent pools, or, at least, where there was not a perceptible lowering of the water, where eggs could be laid at the borders.

About the middle of May of the present year, in a letter addressed to Professor Smith, of New Jersey, we stated that larvæ had then just begun to appear in the large tidal creeks on the reclaimed land opposite San Mateo, and questioned the fact that in this case the eggs were laid in the mud. Our observations since that time, however, tend to show that, even here, the eggs were laid in the mud of the creek borders. We were led to doubt the habit of depositing eggs in the mud here because up to this time no larvæ had appeared, and there was no perceptible lowering of the creek, while in the smaller pools larvæ had been appearing for a couple of months.

We now believe that this lateness of the larvæ was due to the temperature of these large bodies of water not being sufficiently high to favor the development of the eggs. These creeks were also seen to lower considerably later in the season, which would afford abundant opportunity for egg laying at the borders in the previous season. Moreover, larvæ in the smaller pools appeared more abundantly each month until June, despite the fact that no adults were seen in the vicinity during the present season. This can be accounted for only through the fact that the eggs which were laid during the previous season did not all hatch with the high tides of early spring, the great majority not appearing until the higher temperature of May and June.

The larvæ of this species are not confined to brackish water only, or to normal sea water, but may develop abundantly in water of a higher saline content than even sea water. The water in a number of instances where *lativittatus* larvæ were found tested 4.5 per cent of salt, or 1 per cent higher than normal sea water.

An experiment to test the effect of a change of these larvæ to fresh water was made, and a number were placed in pure rain water, but they seemed to enjoy the change and went through their development in due course of time.

The typical places where *lativittatus* larvæ were found were the pools and depressions bordering the edge of the marsh, where only the water of the monthly high tide found its way. After the rains had ceased in the spring the broods appeared as regularly as the tides themselves, as may be seen from the table on the opposite page. These larvæ were first seen on February 20th in 1905, and the last brood in 1904 disappeared on September 25th. They were generally found in pools or situations which contained rather clean water, but in the diked area they were found in water highly impregnated with a reddish mineral deposit, probably ferric iron. This gave the water a distinctly reddish-brown color, and the larvæ and pupæ taken from such pools were covered over with a coating of the same deposit.

Table showing Relation of Tides to Appearance of Broods of Ochlerotatus lativittatus.

The heights, in feet and tenths, are from the soundings of the Coast and Geodetic Survey for this region. The appearance of broods was checked up from our notes. The observations were made on practically the same pools extending for five miles along the marsh, and which were reached only by the monthly high tide, and which dried up in from ten days to three weeks.

Day	MAY.			JUNE.			JULY.		
	Moon.	Height — High Water.	Appearance of Mosquitoes.	Moon.	Height — High Water.	Appearance of Mosquitoes.	Moon.	Height — High Water.	Appearance of Mosquitoes.
		Feet.			*Feet.*			*Feet.*	
1		5.2			5.5			5.8	
2		5.2		New	5.6		New	5.8	
3		5.2			5.6			5.8	
4	New	5.2			5.6				
5		5.2						5.7	
6					5.5			5.4	
7		5.3			5.3			5.2	
8		5.3			5.0			5.4	
9		5.2			5.1		1st quarter	5.4	
10		5.0		1st quarter	5.3			5.6	
11	1st quarter	4.8			5.5			5.8	
12		4.5			5.7			5.9	
13		5.3			6.0			6 1	
14		5.5			6.1			6.2	Larvæ
15		5.7			6.2	Larvæ		6.1	Larvæ
16		5.9		Full	6.2	Larvæ	Full	6.0	Larvæ
17		6.1			6.1	Larvæ		5.7	Larvæ
18	Full	6.1	Larvæ		5.8	Larvæ			Larvæ
19		6.1	Larvæ			Larvæ		5.4	Larvæ
20			Larvæ		5.5	Pupæ		4.9	Pupæ
21		5.9	Larvæ		5.1	Pupæ		4.9	Pupæ
22		5.4	Larvæ		5.0	Pupæ		5.0	Pupæ
23		5.2	Larvæ		5.1	Adults		5.0	Adults
24		4.9	Larvæ	3d quarter	5.2		3d quarter		
25	3d quarter	5.0	Pupæ		5.2			5.2	
26		5.1	Pupæ		5.3			5.3	
27		5.2	Pupæ		5.4			5.5	
28		5.3	Pupæ		5.5			5.6	
29		5.3	Adults		5.6			5.8	
30		5.4			5.8			5.9	
31		5.5					New	5.9	

In the newly reclaimed land north of San Mateo there are some areas which contain numerous cracks in which the water stands at a couple of feet below the surface. A search in these failed to find any larvæ, and we were informed by people living on this land that they were seldom troubled with mosquitoes. That they were not found in such situations may be due to the high mineral content of the water, or that they are not favorable places for egg laying. The chemist of the salt works in the vicinity stated that there was seldom any life found in these deeper cracks, because of the mineral matter contained in the water. The appearance of larvæ in the cracks in the diked area was confined to the early part of the season, none being seen after April, and these may have come in as the water became lowered from the surface level where it stood before the dike was put in repair.

Habits of the Adult.—This mosquito, hatching from its breeding place on the salt marsh, makes its way inland, usually in the direction of favorable winds. During June, 1904, they were found abundantly in the hills beyond the Spring Valley lakes, a distance of 10 miles from the salt marsh. They are active all day, but particularly late in the

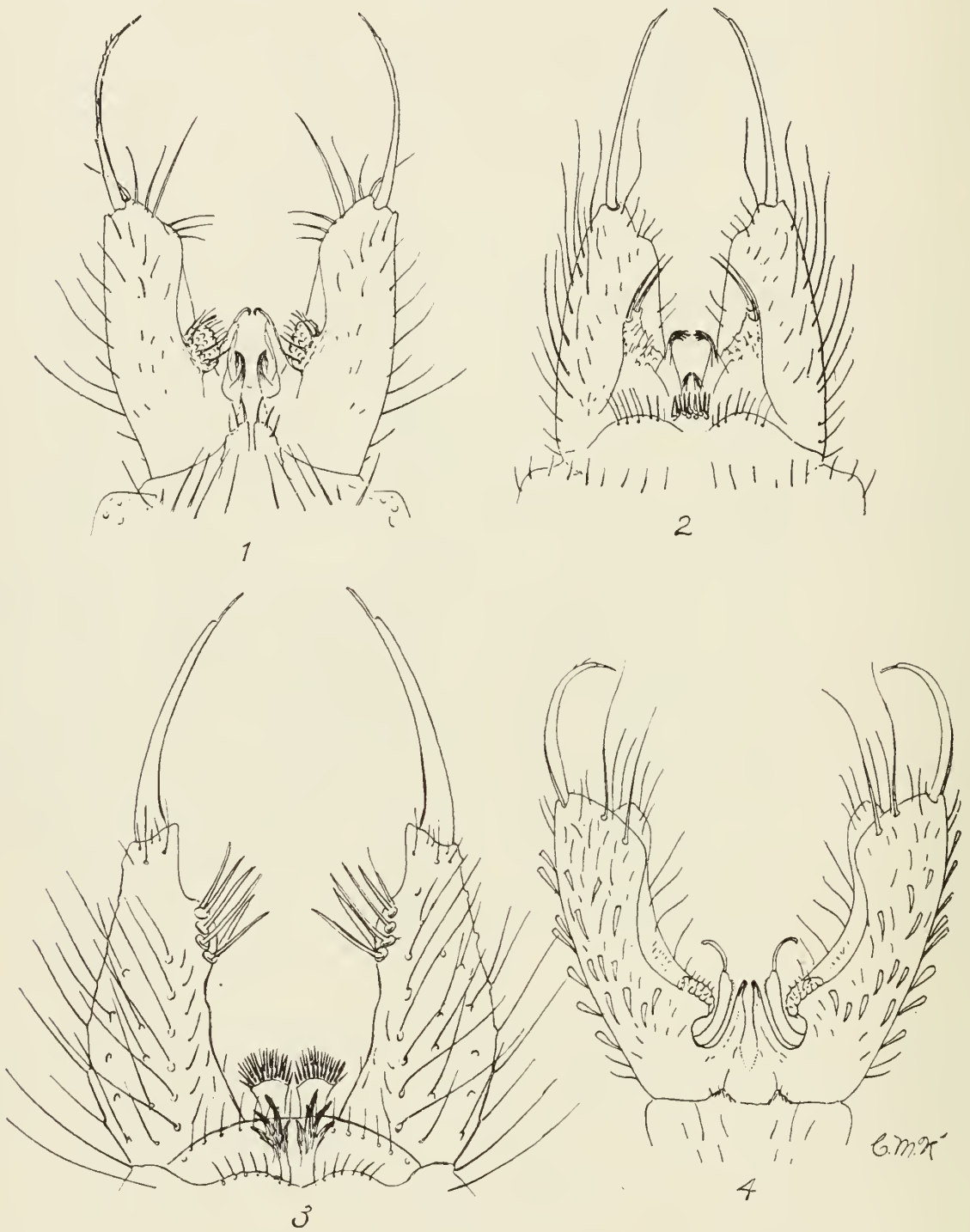

FIG. 27. Genitalia.

1. *Ochlerotatus lativittatus.*
2. *Theobaldia incidens.*
3. *Culex tarsalis.*
4. *Lepidoplatys squamiger.*

afternoon and early evening, when there is but little wind. They have been seen to congregate in innumerable numbers in the wooded cañons of the hill slopes in the Burlingame section, and make life interesting for man as well as stock. This species is particularly bold and vicious, and does not hesitate to thrust its beak through a couple of thicknesses

of clothing. It is not as troublesome in houses and is seldom found there, but prefers the sheltered places out of doors. It can, however, readily make its way through ordinary mosquito netting, as was observed in our breeding cages, which were first covered with this article. And

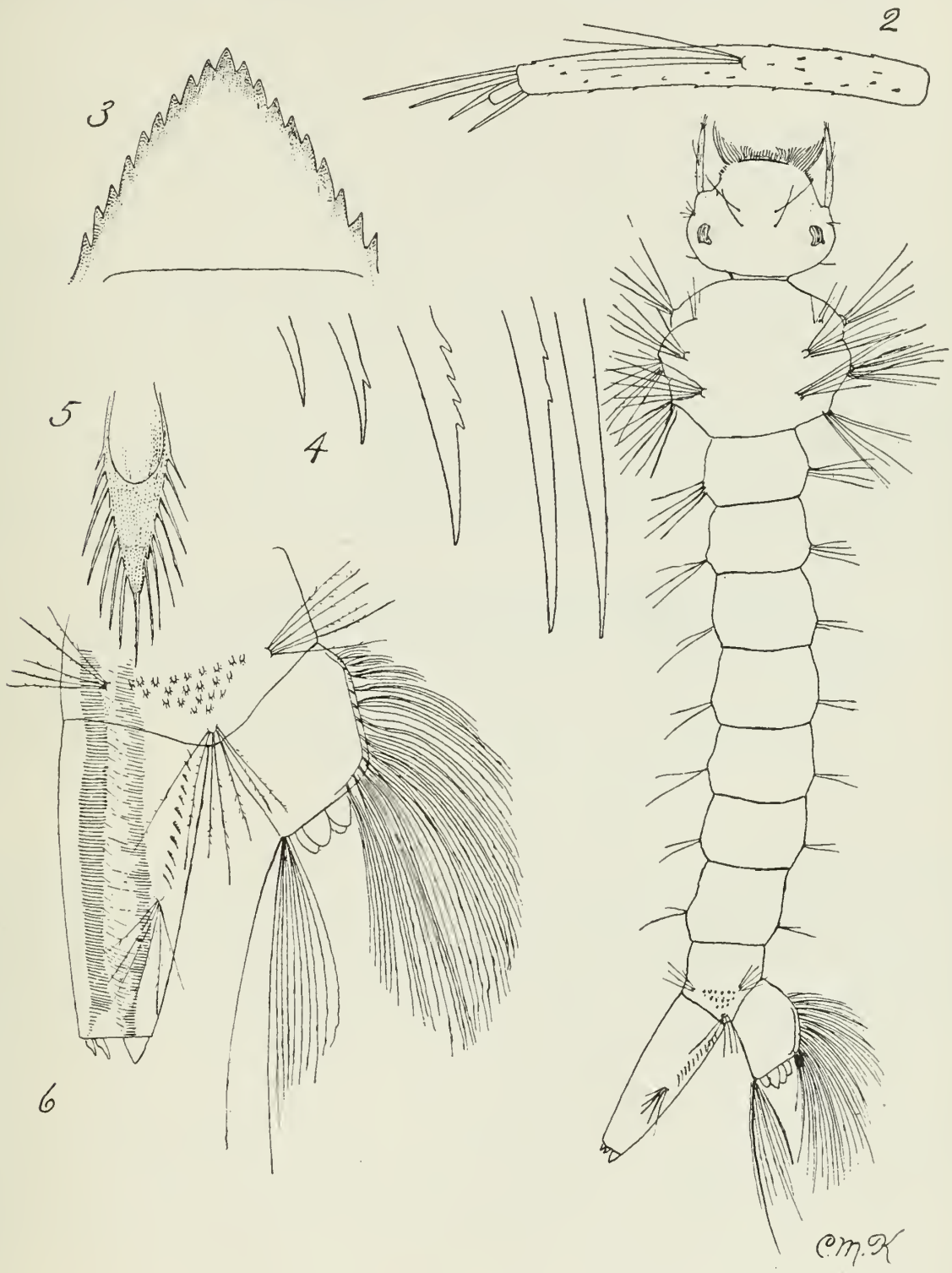

FIG. 28. *Ochlerotatus lativittatus.*

1, larva; 2, antennæ; 3, mentum; 4, spines on breathing siphon, showing variation; 5, scale of eighth abdominal segment; 6, eighth and ninth abdominal segments and siphon; all enlarged.

here it might be stated that there should be a demand created for netting of a finer mesh than that now in common use, to compel the manufacturers to supply this demand. The netting or screens now in the market allow some species to go through very readily, and as we are

writing this, in spite of the fact that the windows of the room are supposed to be well screened, we have captured four species of mosquitoes, two of which are *Anopheles*.

The males of this species were found nowhere except on the marsh or in very close proximity to their breeding ground. The females that were found on the hills during the present year were not found to contain eggs; but since there was but a single brood, and these not very abundant, further observations are necessary before it is safe to form a conclusion as to whether or not the migratory forms are barren.

Description of Larva.—Length of full-grown larva to tip of breathing tubes, 7-8 mm. Head broadest opposite the eyes. There is a tuft of three or four hairs near the base of the antennæ and one or two smaller ones more posteriorly. A rectangle is formed by four single hairs about the middle of the vertex. The antenna is of moderate length, of about the same thickness throughout, slightly curved inward, and bearing short scattered spines upon its surface. At its middle point is a small tuft of four or five hairs, and at the apex is one long and three

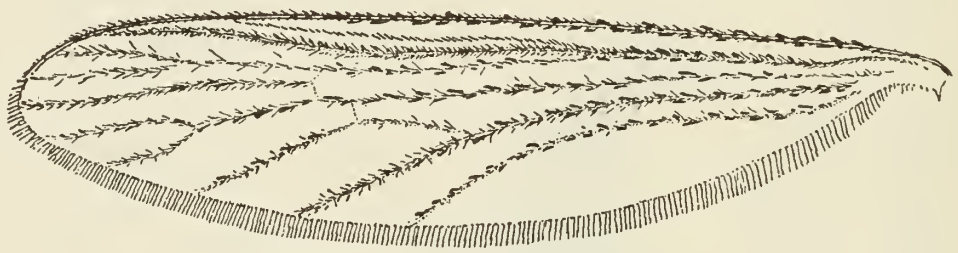

FIG. 29. Wing of *Ochlerotatus lativittatus*, ♂.

shorter spines, and a blunt, peg-like process. The mouth brushes are rather large, with the hairs on the inner side curved at the tip and pectinated. The mentum is normally triangular, with 9 to 10 uniform teeth on each side of the apex. On the eighth abdominal segment are 22 to 25 scales, with spines at the tip and along the sides pointing in the same direction. The respiratory siphon is about two and one half times as long as wide at base; the lateral rows of spines, extending about half-way to apex, consist of 18 to 20 spines, rather long and toothed at the sides. The ninth segment is longer than broad, with two or three dorsal and a row of 12 to 15 ventral tufts at apex. The tracheal gills are shorter than the segment.

Description of Adult.—A very light brown mosquito, almost straw color, with brown stripes on thorax. It is of medium size, and the hind tarsal joints are banded at both base and apex, the last one being wholly white.

Head black; scales light yellow, with darker erect forked ones posteriorly; palpi and beak dark brown.

Thorax with golden-brown scales, a strip of brown ones on each side of median line; femora and tibia yellowish brown, darker at apices. Tarsi light brown, the front one having base and apex of first two joints and base of third white; the middle one with base and apex of first three and base of fourth white; the last one with the first four joints at base and apex and the fifth wholly white. The claws are all one-toothed.

Wings with mixed yellowish white and brown scales, which are broadened at tip. Petiole of first submarginal cell not quite as long as that cell; cross vein at apex of second basal cell its own length from the cross vein above.

Scales on abdomen yellowish white; two large rectangular spots of dark brown scales on each side of median line of segments two to five the appearance of two broad interrupted bands.

Genitalia.—Basal clasp segment stout; the apical segment slender, with a slight constriction near base, widest at middle, and ending in the usual spine. Claspette at basal third of clasp segment; a row of strong spines on margin. Basal portion of harpes setaceous, with three or four long spines on inner side near apex. Terminal segment smooth, and as long as basal part. Harpago stout, bent, ending in an acute-recurved hook. Setaceous lobes prominent, bearing from three to six stout spines. (See Fig. 27.)

Size, 6 mm. Wing expanse, 10-12 mm.

Lepidoplatys squamiger.

Habits of Younger Stages.—So far as our acquaintance goes with this mosquito during the past season, it is wholly a salt-marsh form. We were on the lookout for this species in fresh-water pools during the season, because Professor Smith found what had been determined as *squamiger* in New Jersey to be limited entirely to fresh water. After Professor Smith's attention was called to this difference in habits he wrote us that upon closer examination it proved to differ from the typical California *squamiger,* and that it was a new species. It is said that this *squamiger* was taken at San Rafael in 1904 in one or two cases in fresh-water pools. It is not improbable, of course, that this species may be found in fresh water, but if one season's experience will justify the conclusion it is the exception to find it in such situations in this particular region.

The larvæ of this species were almost invariably found in the identical situations with *lativittatus,* which has already been fully discussed. The striking difference in habits of the two, however, is in the fact that *lativittatus* is many-brooded, while *squamiger* is limited to probably two. *Squamiger* larvæ were about as common as *Ochlerotatus lativ-*

ittatus in the early season, but they were not seen after April. They first appeared with *O. lativittatus* February 20th, but disappeared by the last week in April.

Having left the State about September 1st we were unable to follow it later than that date, but the control work of the present season would, in all probability, have prevented any further broods from appearing anyway. However, in a trip made to the territory on September 20, 1904, adult *squamiger* were flying about rather abundantly, and males

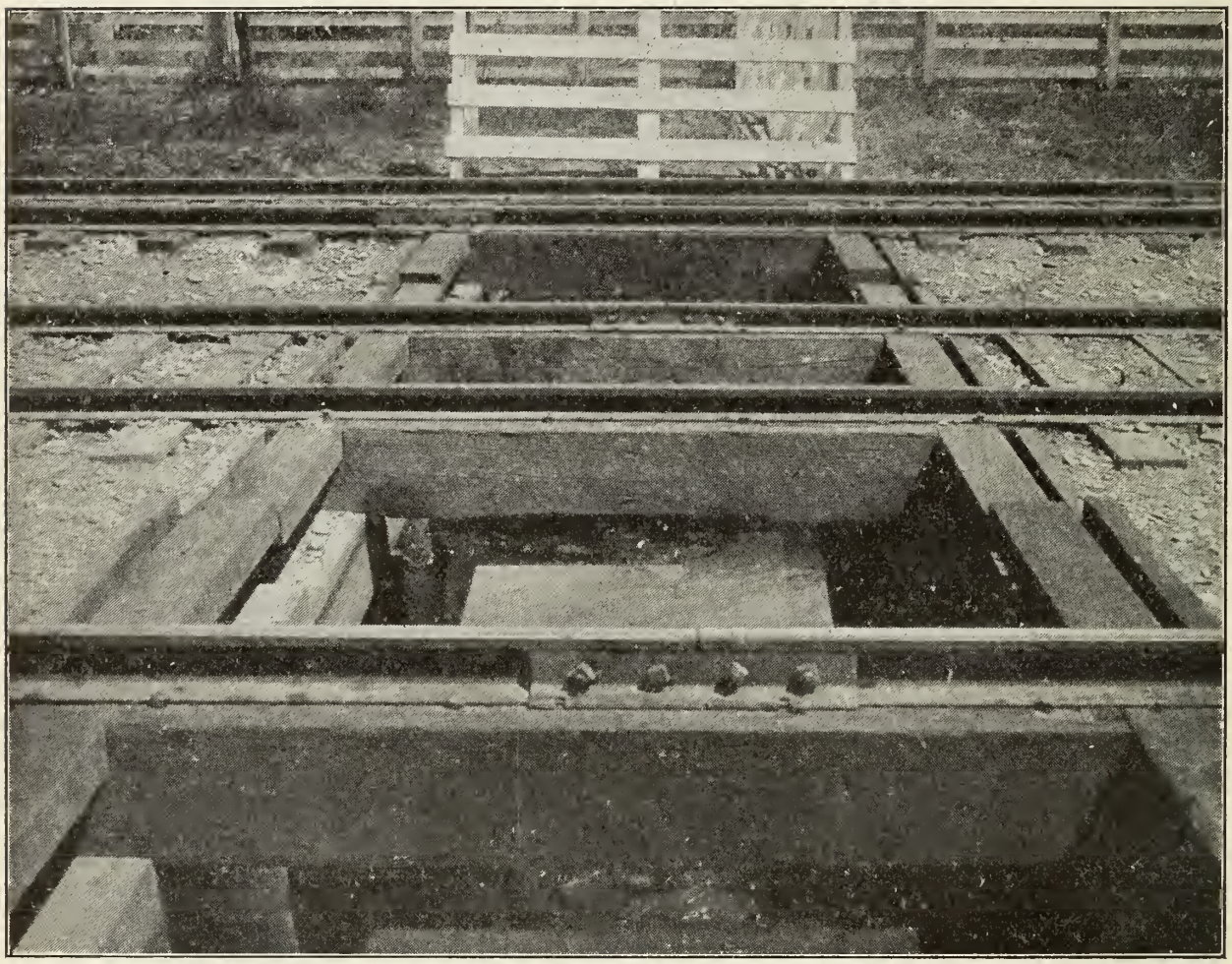

FIG. 30. A cattle-guard on the Southern Pacific railroad. A case where man helps the mosquitoes.

were found on the marsh, which would indicate that a brood had recently emerged.

Negative evidence points to the fact that, like *O. lativittatus,* the eggs remain over winter and hatch in the following February or March. Owing to the early disappearance of the species we were given no opportunity for studying the egg-laying habits; but since the larvæ were found in the same situations with *O. lativittatus,* it is likely that the egg-laying habit is similar in the two species.

Habits of Adult.—This species is also migratory, and while it was not found across the hills toward the ocean, as was *O. lativittatus,* it was

found abundantly enough at Burlingame and San Mateo, and in the hills at least three or four miles from its breeding ground.

This was the only species that appeared in numbers during the past season in Burlingame, and this was due to an early brood which

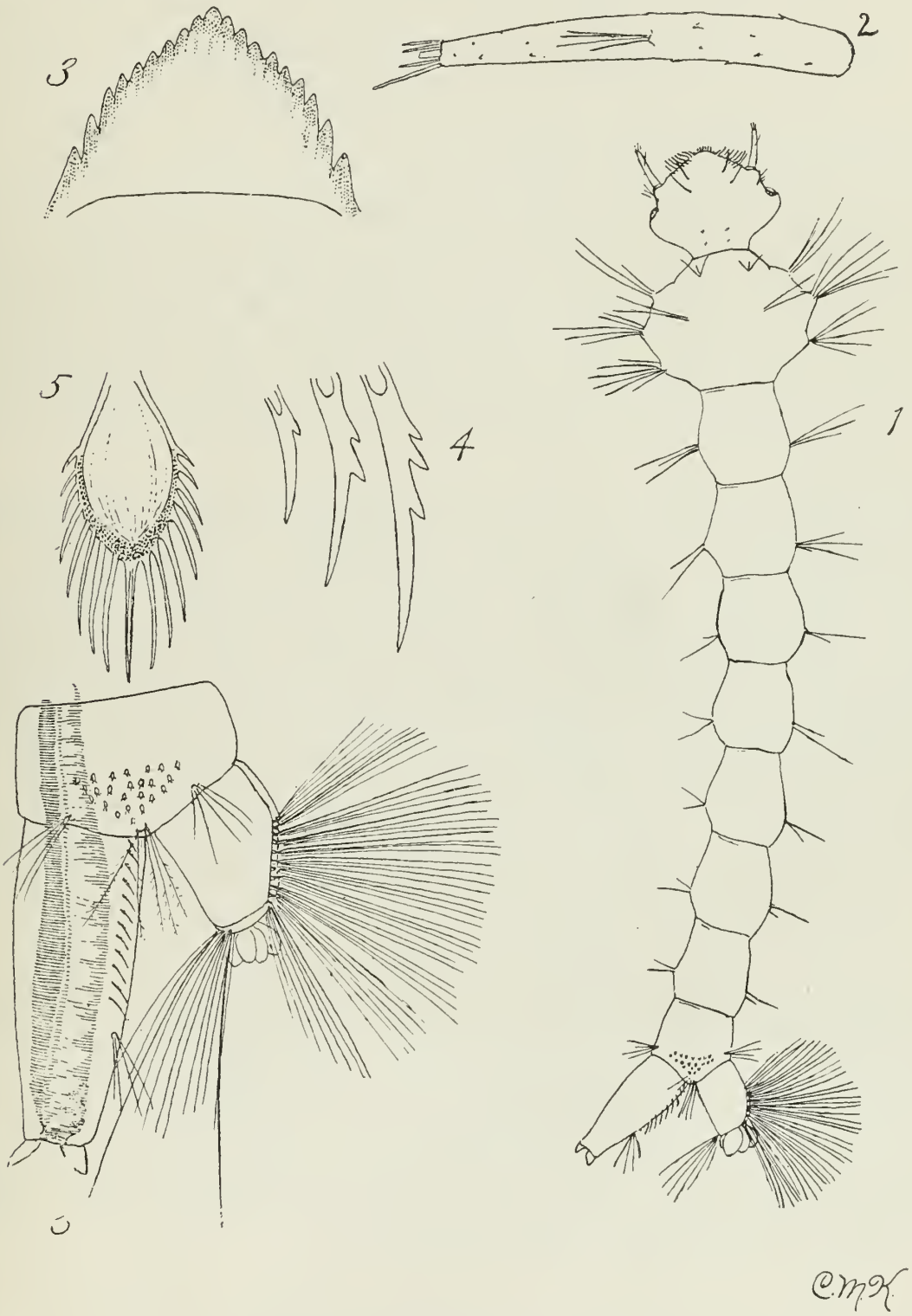

FIG. 31. *Lepidoplatys squamiger.*

1, larva; 2, antennæ; 3, mentum; 4, siphonal spines, showing variation; 5, scale of eighth abdominal segment; 6, eighth and ninth abdominal segments and siphon; all enlarged.

emerged from the diked area. No adults emerged, to our knowledge, after March 25th, but a few still persisted in the residence section until July 1st, which would seem to indicate that the maximum adult life may be three months. In our notes it is recorded that on May 16th

adults of *squamiger* were common on the marsh, and all were females with eggs well developed. The egg-laying, therefore, may be prolonged for nearly two months after emergence; altogether, our notes on this species indicate that it is longer lived than the others of this section. Its biting propensities are about as well developed as the brown marsh species, and the only thing that prevents it occupying a place of annoyance equal to *O. lativittatus* is that it is fewer-brooded, and consequently less in numbers.

In 1905 the first adults of this species were seen on February 27th and the last on July 2d. In 1904 a brood was observed in the middle of September. Three or four specimens taken in the hills, in April, about three miles from the marsh, had eggs partly developed, but these were the only ones seen with eggs, excepting on the marsh. The great majority of those that made their way to the hills never returned to the marsh. No adults were seen on the marsh after the middle of May, although they were seen in the hills up to July 1st.

Description of Larva.—Length of full-grown larva to tip of breathing tubes, 10 mm. A robust larva usually of a dark gray color. Head broader than long, widest just posterior to the eyes. Near the base of the antennæ is a tuft of four or five hairs. The antennæ are short, slightly curved inward, with a small tuft of hairs at the middle not reaching to apex, and with scattered spines over its surface. The apex is terminated in one long spine, often crooked, one about one half as long, and two shorter ones, and with a small, peg-like process. The mouth brushes are composed of a thick mat of hairs curving inward, those on the inner side being sharply curved at tip and finely pectinated. The mentum is broadly triangular, with 9 to 10 uniform teeth on each side of apex. The lateral patches of scales on the eighth segment are composed of from 26 to 30 scales, each scale being armed at the tip with spines, those at the tip being the longest. Respiratory siphon not more than three times as long as broad at base, two rows of toothed spines extending from base to about middle; near the end of row is a small tuft of four or five hairs. Ninth segment longer than broad, bearing two dorsal tufts and a ventral row of twelve or fifteen tufts. Tracheal gills short, not exceeding width of segment.

Description of Adult.—A rather large mosquito, with very scaly wings. Scales mixed with white and black, giving a general color of gray. Base of tarsal joints and segments of abdomen white.

Head black, with whitish scales on posterior part; palpi with beak lighter brown in middle, with apical fourth darker; antennæ dark brown.

Scales of thorax pale yellow, mixed with black along the sides and with a dark-brown median band dorsally; there are also golden-brown

scales sparsely scattered over thorax. The femora are pale brown, lighter beneath, and covered with white and black scales, more numerous above. The tibia are darker in color, with mixed white and black scales, and on either side below are rather long black hairs, also present on femora and tarsi. The tarsi are black, with occasional white scales; the bases are banded with white or pale yellow scales, more prominent on hind tarsi; claws single-toothed.

The wings are densely clothed with white and dark-brown scales, giving a general color of gray. The scales on the dorsal two thirds mostly broad and truncate, while on the apical third long, narrow ones, tapering slightly at each end, are more numerous. Petiole of submarginal cell about two thirds as long as is cell; cross vein at apex of second basal at least equal to its length from the one above it.

The abdomen is black, with scattered whitish scales; the base of the segments with rather broad band of similarly colored scales.

Genitalia.—Basal segment strongly curved on inner side, broadening just before tip. Apical segment rather strongly curved at tip, ending in an articulate spine. Claspette setaceous, and situated at base of basal segment. Harpes long, jointed, ending in blunt process, which surrounds base of apical joint; inner side strongly setaceous. Apical joint abruptly bent at basal one third and curved at tip. Harpago not quite reaching to apex of basal joint of harpe. Tip heavily chitinizell and recurved. Setaceous lobes acutely pointed, bearing two or three long spines at tip. (See Fig. 27.)

Size, 7 mm. Wing expanse, 12-15 mm.

Theobaldia incidens.

Habits of Early Stages.—This is the commonest fresh-water mosquito in the bay region, and may be found in every conceivable place where there is standing water. The small pools and containers of water about residences are sure to be stocked with this mosquito. It may breed in very foul water, and has been found at the outlet of sewers. It is also the commonest species breeding in the creeks in this section. The eggs occur in raft-like masses of a hundred or more. They are very conspicuous floating upon the surface of the water. Larvæ of this species have been found from January to November.

Habits of Adult.—This is the typical house mosquito of the section, and will find its way into houses if there is any opportunity for entering. Next to the salt-marsh species it is the most troublesome, and is a ready biter. Specimens may be found at any season of the year, though they are not active for two or three months during the winter. At this

season they have been found in cellars, under stone bridges and other protected places, and seemed to be partly hibernating. The species may be met with at any time of day, but are more in evidence toward evening. So far as is known it goes but a few hundred yards from its

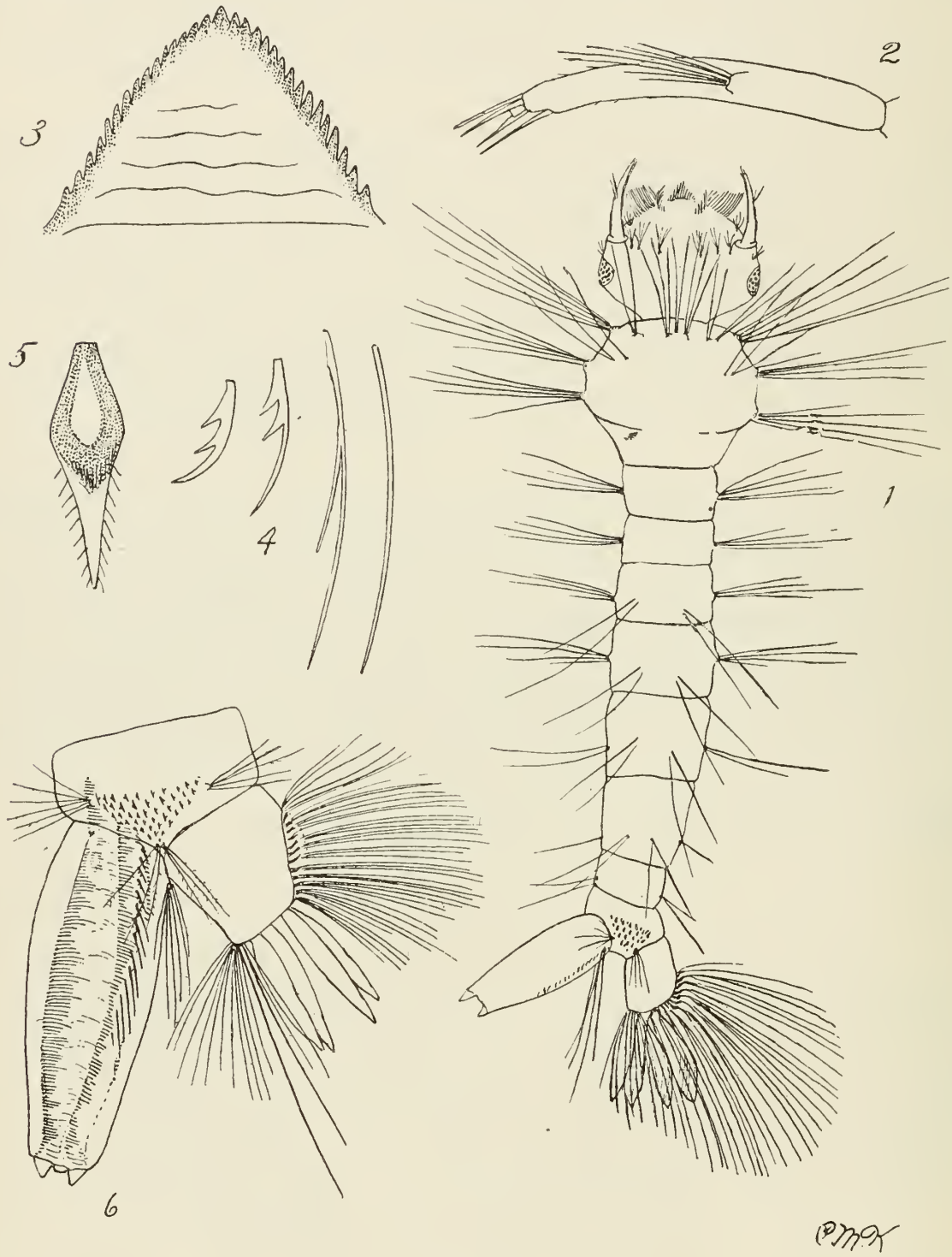

FIG. 32. *Theobaldia incidens.*
1, larva; 2, antennæ; 3, mentum; 4, siphonal spines, showing variation; 5, scale of eighth abdominal segment; 6, eighth and ninth abdominal segments and siphon; all enlarged.

breeding place, and if it is troublesome in the house its breeding ground will more than likely be found on the premises.

Description of Larva.—Length of adult larva to tip of breathing tube, 10-11 mm. A robust larva of dark gray or greenish color. Head

broadest posteriorly; on vertex, forming a slight arch with the antennæ, are six tufts of hairs, three on each side of median line, the two central ones being farthest apart. The antennæ are short, curved inward, slightly tapering toward tip, with a tuft of hairs on upper side slightly proximal to middle, and bearing at its tip four spines, two at the extreme tip and two just back of tip, and an articulated truncate peg. The mouth brushes with hairs on inner side slightly curved at tip and finely pectinated. The mentum triangular, with 12 to 14 teeth, slightly larger toward base, on each side of apical tooth, which is largest. Scales on eighth abdominal segment arranged in triangular form and numbering 50 to 55. Each scale bears rather long spines, which are not spreading. Respiratory siphon three times as long as width at base; on each side, extending about two thirds of the way to apex, are two rows of spines, those at the proximal one third toothed, while the rest are long, slender, and hair-like. The ninth segment is slightly longer than broad, with three or four tufts on dorsal side, and a row of 12 to 15 on ventral side. The tracheal gills are about one and one fourth times the length of segment.

Description of Adult.—A large mosquito, with prominent black spots on the wings. The only other California species, excepting *Anopheles,* with spotted wings is *annulatus,* which may be distinguished by the bands on middle of tarsal joints. Head black, with golden-brown scales on occiput, erect forked ones on posterior margin; in front are long, curved, black bristles, projecting forward. The eyes are immediately surrounded with a narrow stripe of straw color; palpi annulate with dark brown, becoming darker at tip. Antennæ dark brown.

Thorax with black and golden-brown scales, and numerous black bristles, those over base of wing brown. Two narrow prominent stripes of black scales extending one each side of median line from anterior edge to base of wings.

Wings clothed throughout with narrow linear scales. A cluster of such scales occurs on radius 2 just anterior to cross vein connecting with radius 4, one at point of branching of radius 1 and 2, and a third at the junction of medial 1 and 2. Petiole of first submarginal cell about one half the length of that cell; cross vein at apex of second basal cell meeting, or very nearly, with the one above it.

Femora dark brown to black above with scattered white scales, below and at extreme tip white; tibia black above, whitish below, and narrowly banded at tip with white; tarsi of almost uniformly dark brown, with very faint markings of yellow at apices. Claws simple.

Genitalia.—Basal segment of clasp short and stout, suddenly narrowed on inner side near apex. Terminal clasp segment tapering gradually to tip. Claspette a prominent pyramidal lobe, bearing two stout

spines at apex. *Harpagones rather broad, straight, central processes, ending in a curved hook. Setaceous lobes obtusely rounded, with 7 to 9 slender spines. Between these is a median lobe, bearing eight very stout and bluntly pointed spines. (See Fig. 27.)

Size, 7 mm. Wing expanse, 15 mm.

Culex tarsalis.

Habits of Younger Stages.—The larvæ of this species were found in the same situations as *incidens*. It is not so widespread, however, and *incidens* may be found without *tarsalis*, but the converse of this was seldom observed. It was never found in foul water, and seems to prefer the clearer pools. No pool was seen swarming with these larvæ, and they appear not to be as rapid breeders as *incidens*.

Habits of the Adult.—Little opportunity was afforded for studying the habits of the adult of this species, since they were but rarely met with. Those that were seen occurred with *incidens*, and it is probable that the habits of the two are somewhat similar.

Description of Larva.—Length of adult larva to tip of breathing tube, 8-9 mm. Head broadest at eyes, abruptly narrowed before the antennæ; on vertex just above the antennæ is a tuft of 6 to 7 hairs, two similar tufts on each side of median line on the middle of vertex, and a small tuft of three or four hairs above and below the eyes. The antennæ are long, slightly curved inward, of about the same thickness to the tuft, where it suddenly narrows, the whole surface being covered with scattering hairs; the tuft is on the apical one third and consists of 20 to 30 hairs. At the tip are three long spines and one short one, and a short, stout peg; the antennæ are narrowed slightly at the base, and arise from a shoulder of the head.

The mouth brushes are long and wide apart, with long scattered straight hairs on the inner side. The mentum is rather sharp pointed and with 9 to 10 teeth on a side, the apical one, and the second and third, being the largest. The scales on the eighth segment number 32 to 35, with walled spines at the tip and sides. The respiratory siphon is at least four times as long as broad at base. The rows of spines, consisting of 12 to 15, extend about one third way to apex; the spines are broad, short and many-toothed; there are three or four tufts at middle and one near the apex. The ninth segment about as long as broad, with the usual apical tufts of hairs. The tracheal gills are about one and one fourth times the length of segment.

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* Dr. Felt, N. Y. State Museum Bulletin 97, p. 480, records these as wanting, while Dr. Dyer, N. Y. Jour. Ent. Soc., Vol. XIII, p. 55, describes them as "cylindrical and truncate." If we have homologized the parts correctly they are distinctly visible, particularly in potash preparation.

Description of Adult.—A medium-sized mosquito with brown thorax, and black abdomen with white bands. Beak banded, and tarsal joints white at both base and apex.

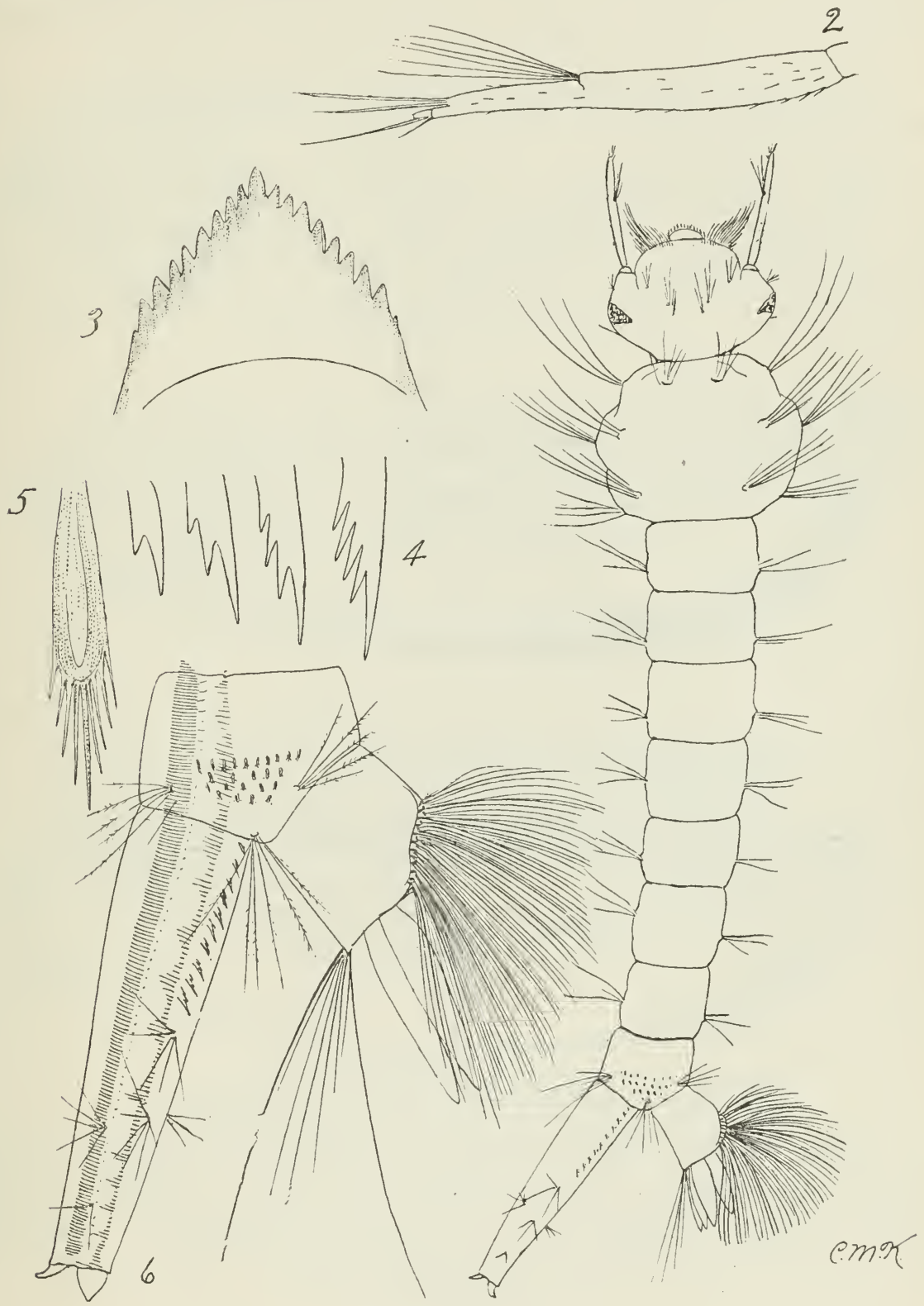

FIG. 33. *Culex tarsalis.*

1, larva; 2, antennæ; 3, mentum; 4, siphonal spines, showing variation; 5, scale of eighth abdominal segment; 6, eighth and ninth abdominal segments and siphon; all enlarged.

Head with yellowish-brown tomentum on occiput and furcate at tip; palpi uniformly black; beak black, with broad band of white at middle.

Thorax brown to black, with golden-brown tomentum on dorsum; pluræ whitish; femora black above, and below and at tips white; tibia

black, with base and apex white; tarsi black, and banded with white at both ends. Claws all simple, bearing no teeth.

Wings with dark-brown slender scales throughout. Petiole of first submarginal cell about one half the length of that cell; cross vein at end of second basal less than its length from the one above it.

Abdomen black, with well-defined bands at base of segments; venter white.

Genitalia.—Basal segment of clasp curved, suddenly narrowed on inner side near tip. Apical segment stout, tapering to tip; terminal spine present. Claspette, situated on apical one third of basal segment, is composed of a conspicuous spatulate organ, two curved spines, and

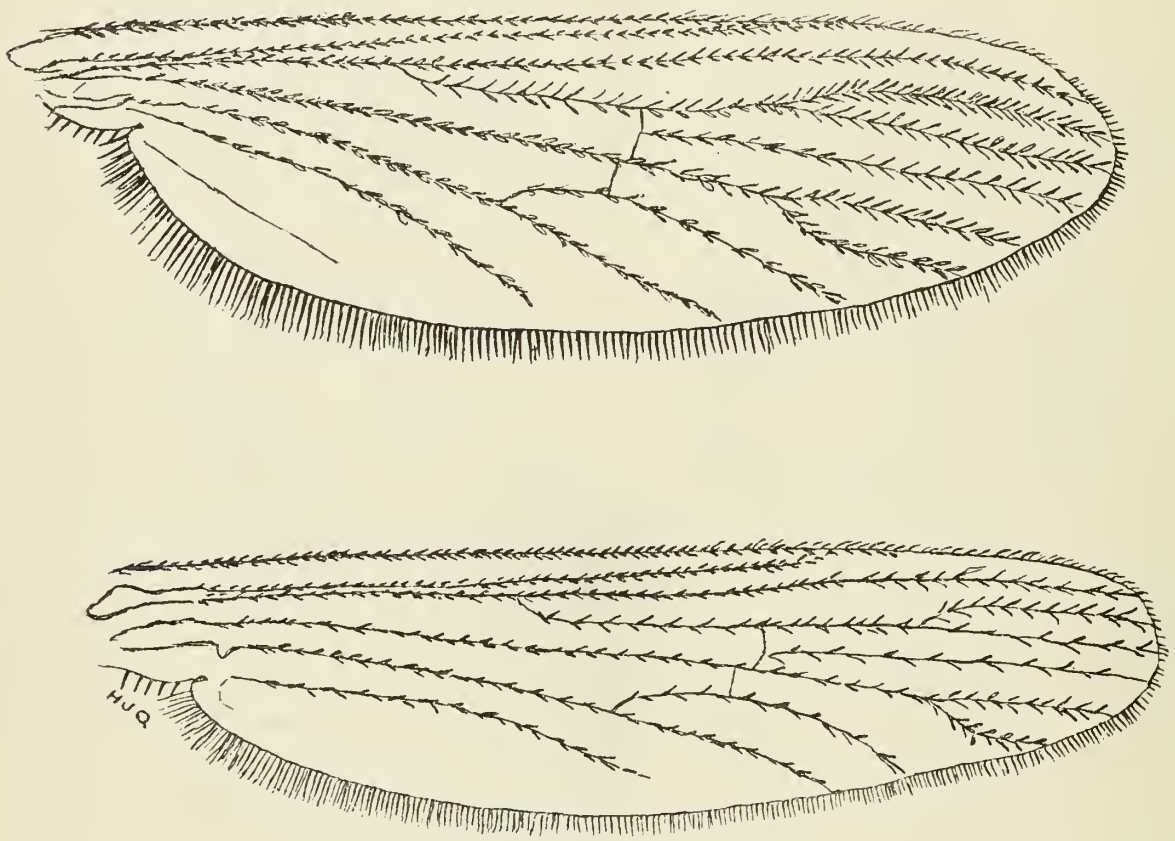

FIG. 34. Wings of *Culex tarsalis*: ♀ above; ♂ below.

three closely set stout spines, which are generally recurved at the tip. Harpes stout, bearing at apex a tuft of stout spines. Harpago bearing at its tip conspicuous stout teeth arising in different planes. Setaceous lobes broadly rounded and bearing slender spines. (See Fig. 27.)

Other Species.

Besides the four troublesome species already described in detail there were found early in the season in a cattle-guard on the Southern Pacific Railroad at Millbrae the larvæ of *variapalpus,* and a few adults were also taken in the vicinity. Nothing was seen of this species after the middle of April, though, of course, the control work may have had something to do with this.

Anopheles maculipennis was taken from the pond along the carline one half mile north of the Burlingame depot, and also from another pond on the west side of the county road opposite the Blackhawk dairy. The larvæ were fairly common here, and males were collected from the

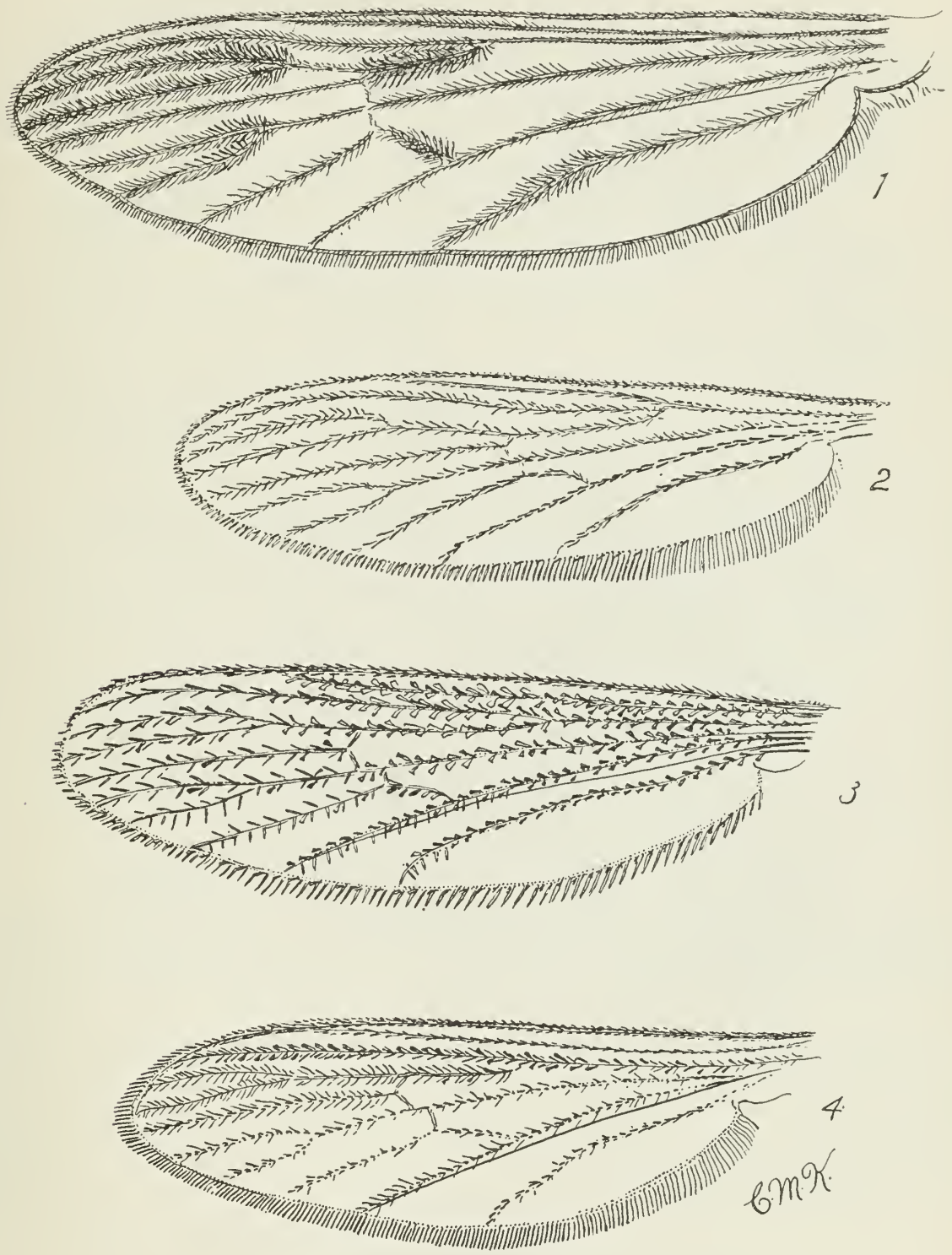

FIG. 35.

1. *Theobaldia incidens* ♀
2. *Culex tarsalis* ♀
3. *Lepidoplatys squamiger* ♀
4. *Ochlerotatus lativittatus* ♀

grass by sweeping. A trip was made to San Rafael on June 8th, and the marshes to the east of the town were visited. Here, in the wide tidal creeks in land that was partly reclaimed, we expected to find *O. lativittatus* larvæ, but were surprised to find *Anopheles maculipennis* the commonest form, although the water was distinctly brackish.

SYNOPTIC TABLES.

The following synoptic tables include all the species known to occur in California at the present writing:

Table for determining the Genera and Species of California Culicidæ.

a. Legs densely clothed with coarse erect scales ..... *Psopophora ciliata.*
a. Legs not densely clothed with coarse erect scales.
  b. Palpi, in females, as long as beak ..... *Anopheles.*
    c. Palpi of uniform color.
      d. Wings with conspicuous rectangular yellowish-white spots on apical fourth of front margin ..... *A. punctipennis.*
      dd. Wings without such spots ..... *A. maculipennis.*
    cc. Palpi banded; light area at base of three distal segments ..... *A. franciscanus.*
  bb. Palpi in female not as long as beak.
    c. Tarsal claws toothed.
      d. Lateral wing scales narrow, but slightly tapering to bases ..... *Ochlerotatus.*
        e. Apices of palpi and ring at middle white ..... *O. varipalpus.*
        ee. Palpi not so marked.
          f. Last joint of hind tarsi wholly white ..... *O. lativittatus.*
          ff. Last joint of hind tarsi not wholly white .. *O. sylvestris.*
      dd. Lateral wing scales generally broad, tapering to bases ..... *Lepidoplatys squamiger.*
    cc. Tarsal claws not toothed.
      d. Cross vein at end of second basal cell more than its length from the one above it ..... *Culex.*
        e. Beak banded ..... *C. tarsalis.*
        ee. Beak not banded.
          f. Segments of abdomen banded at apex ..... *C. territans.*
          ff. Segments of abdomen banded at base .... *C. pipiens.*
      dd. Cross vein at end of second basal cell less than its length from the one above it.
        e. Wings spotted ..... *Theobaldia.*
          f. Tarsal joints banded at middle ..... *T. annulatus.*
          ff. Tarsal joints not banded at middle ..... *T. incidens.*
        ee. Wings not spotted ..... *Culiseta consobrina.*

CULICIDAE IN CALIFORNIA.*

1. **Anopheles maculipennis** Meig. (*quadrimaculatus* Say, *annulimanus* Wulp).

ALDRICH, J. M. Cat. Diptera, p. 121.
BERKELEY, W. N. Laboratory Work with Mosquitoes. 1902.
DYAR, H. G. Ent. Soc. Wash. Proc., 5:45-51. 1902.
—— Ent. Soc. Wash. Proc., 6:37-41. 1904.
—— N. Y. Ent. Soc. Jour., 11:23-27. 1903.
—— N. Y. Ent. Soc. Jour., 13:23. 1905.
FELT, E. P. N. Y. St. Mus. Bull. 79. (*See* Index.)
—— N. Y. St. Mus. Bull. 97. (*See* Index.)
GILES, G. M. Gnats or Mosquitoes, p. 326. 1900.
HOWARD, L. O. U. S. Dept. Agr., Bur. Ent., Bull. 25, n. s., 1900.
—— Mosquitoes. 1900.
JOHANNSEN, O. S. N. Y. St. Mus. Bull. 68. 1903.
LUDLOW, C. S. Medical Record, January 20, 1906.
SMITH, J. B. N. J. Agr. Ex. Sta. Bull. 171.
—— N. J. Report on Mosquitoes, p. 168. 1904.
THEOBALD, F. V. Monograph.

2. **Anopheles punctipennis** Say (*hiemalis* Fitch).

ALDRICH, J. M. Cat. Diptera, p. 122.
DYAR, H. G. N. Y. Ent. Soc. Jour., 10:194-201. 1902.
—— N. Y. Ent. Soc. Jour., 13:23. 1905.
—— Ent. Soc. Wash. Proc., 5:140-48. 1903.
FELT, E. P. N. Y. St. Mus. Bull. 79. (*See* Index.)
—— N. Y. St. Mus. Bull. 97. (*See* Index.)
FITCH, ASA. Am. Jour. Agr. Sci., 5:281-282. 1847.
GILES, G. M. Gnats or Mosquitoes, p. 322. 1900.
HOWARD, L. O. U. S. Dept. Agr., Bur. Ent., Bull. 25, n. s., 1900.
—— Mosquitoes, 1901.
JOHANNSEN, O. S. N. Y. St. Mus. Bull. 68. 1903.
LAWRENCE. Long Island Board of Health Rept. 1903.
LUDLOW, C. S. Medical Record, January 20, 1906.
ROBINSON, F. W. Rept. Eliz. N. J., pp. 1-15.
SMITH, J. B. Rept. N. J. Agr. Ex. Sta. Bull. 171.
—— Report on Mosquitoes, p. 163. 1905.
THEOBALD, F. V. Monograph of Culicidæ.

* This list of California *Culicidae* has been checked up through the courtesy of Dr. L. O. Howard, by Mr. D. W. Coquillett, of the Bureau of Entomology. Washington. Mr. C. S. Ludlow, in the *Medical Record* for January 20, 1906, also records *dorsalis*, *signifer*, and *spencerii* as occurring in the State.

The classification of *Culicidae* has recently undergone considerable change, particularly within the old genus *Culex*, which is in the above list represented by five genera. Most workers in the group are agreed on the genus *Culex* as now restricted, and also on the genera *Theobaldia* and *Culiseta*. There is, however, not a general concurrence on the other two genera, and to aid in the reference to the literature which has appeared during the last year or two, the following synonymy, so far as it concerns the California species, is here given:

Lepidoplatys Coq. = *Taeniorhynchus* Nev. Lem. (Coquillett),
Grabhamia Theob. (Dyar),
Culicada Felt (Felt).

Ochlerotatus Arrib. = *Cylicada* Felt (Felt),
Ecculex Felt (Felt and Dyar),
Taeniorhynchus Nev. Lem. (Coquillett),
Grabhamia Theob. (Dyar).

The species *curriei* has been redescribed by Mr. Coquillett as *lativittatus*.

Professor Smith has since stated that his species is distinct from *squamiger* and that it is a new species.

3. **Anopheles franciscanus** McC.

McCracken, Isabel. Ent. News, Jan. 1904.
Dyar, H. G. N. Y. Jour. Ent. Soc., 13:23. 1905.
Felt, E. P. N. Y. St. Mus. Bull. 97. 1905.
Ludlow, C. S. Medical Record, January 20, 1906.

4. **Culex tarsalis** Coq. (*willistoni* Giles, *kelloggi* Theob., *affinis* Adams).

Aldrich, J. M. Cat. Diptera, p. 132.
Coquillett, D. W. Can. Ent., 28:43-44. 1896.
Dyar, H. G. Ent. Soc. Wash. Proc., 6:37-41. 1904.
—— Jour. N. Y. Ent. Soc., 13:23. 1905.
Felt, E. P. N. Y. St. Mus. Bull. 97. 1905.
Howard, L. O. U. S. Dept. Agr., Bur. Ent., Bull. 25, n. s., 1900.
—— Mosquitoes. 1901.
Ludlow, C. S. Medical Record, January 20, 1906.

5. **Culex territans** Walk. (*apicalis* Adams).

Aldrich, J. M. Cat. Diptera, p. 132.
Dyar, H. G. Ent. Soc. Wash. Proc., 5:140-48. 1903.
—— Ent. Soc. Wash. Proc., 6:37-41. 1904.
—— Jour. N. Y. Ent. Soc., 13:26. 1905.
Felt, E. P. N. Y. St. Mus. Bull. 79. 1904.
—— N. Y. St. Mus. Bull. 97. 1905.
Ludlow, C. S. Medical Record, January 20, 1906.
Smith, J. B. Rept. N. J. Agr. Ex. Sta., p. 325. 1905.

6. **Culex pipiens** L. (*aestuans* Wied., *pungens* Wied., *fatigans* Wied., *boscii* Desv., *cubensis*, Bigot).

Aldrich, J. M. Cat. Diptera, p. 130.
Dyar, H. G. N. Y. Ent. Soc. Jour., 5:45-51. 1902.
—— N. Y. Ent. Soc. Jour., 10:194-201. 1902.
—— N. Y. Ent. Soc. Jour., 13:26. 1905.
—— Ent. Soc. Wash. Proc., 5:140-48. 1903.
—— Ent. Soc. Wash. Proc., 6:40. 1904.
Felt, E. P. N. Y. St. Mus. Bull. 79. (*See* Index.)
—— N. Y. St. Mus. Bull. 97. (*See* Index.)
Howard, L. O. U. S. Dept. Agr., Bur. Ent., Bull. 25, n. s., 1900.
—— Mosquitoes, 1901.
Johannsen, O. S. N. Y. St. Mus. Bull. 68. 1903.
Lawrence. Long Island Board of Health Rept.
Ludlow, C. S. Medical Record, January 20, 1906.
Robinson, W. F. Eliz. N. J. Rept.
Smith, J. B. Ent. News. 15:49-51.
—— Rept. N. J. Agr. Ex. Sta., p. 305. 1905.
Van Dine, D. L. Agr. Ex. Sta. Haw., Bull. 6.

7. **Ochlerotatus varipalpus** Coq. (*sierrensis* Ludlow).

Aldrich, J. M. Cat. Diptera, p. 132.
Coquillett, D. W. Can. Ent., 34:292-93. 1902.
Dyar, H. G. Ent. Soc. Wash. Proc., 6:37-41. 1904.
—— Jour. N. Y. Ent. Soc., 13:25, 28, 54.
Felt, E. P. N. Y. St. Mus. Bull. 97. 1905.

8. **Ochlerotatus lativittatus** Coq. (*curriei* Coq.).

Aldrich, J. M. Cat. Diptera, p. 132.
Coquillett, D. W. Can. Ent. 33:258-260. 1901.
Dyar, H. G. Jour. N. Y. Ent. Soc., 13:25, 54, 187.
—— Ent. Soc. Wash. Proc., 6:40. 1905.
Felt, E. P. N. Y. St. Mus. Bull. 97.
Ludlow, C. S. Medical Record, January 20, 1906.
Quayle, H. J. Ent. News, Jan., 1906.
Theobald, F. V. Monograph.

9. **Ochlerotatus sylvestris** Theob.

ALDRICH, J. M. Cat. Diptera, p. 131.
DYAR, H. G. Jour. N. Y. Ent. Soc., 10:194-201. 1902.
—— Jour. N. Y. Ent. Soc., 13:24. 1905.
—— Ent. Soc. Wash. Proc., 5:140-148. 1903.
—— Ent. Soc. Wash. Proc., 6:37-41. 1904.
FELT, E. P. N. Y. St. Mus. Bull. 97.
LUDLOW, C. S. Medical Record, January 20, 1906.

10. **Theobaldia incidens** Thom. (*panticeps* Adams).

ALDRICH, J. M. Cat. Diptera, p. 126.
DYAR, H. G. Ent. Soc. Wash. Proc., 6:37-41. 1904.
—— N. Y. Jour. Ent. Soc., 13:24, 55. 1905.
FELT, E. P. N. Y. St. Mus. Bull. 97. 1905.
LUDLOW, C. S. Medical Record, January 20, 1906.
THEOBALD, F. V. Monograph of Culicidæ.

11. **Theobaldia annulatus** Schran.

ALDRICH, J. M. Cat. Diptera, p. 126.
FELT, E. P. N. Y. St. Mus. Bull. 97.
OSTEN SACKEN, C. R. U. S. G. & G. S. Survey Bull. 3.
LUDLOW, C. S. Jour. N. Y. Ent. Soc., 10:131. 1902.
—— Medical Record, January 20, 1906.

12. **Culiseta consobrina** Desv. (*impatiens* Walk., *inornatus* Will., *pinguis* Walk.).

ALDRICH, J. M. Cat. Diptera, p. 128.
—— Can. Ent., 35:208-210. 1903.
COQUILLETT, D. W. Can. Ent., 35:218. 1903.
DYAR, H. G. Jour. N. Y. Ent. Soc., 11:23-27. 1903.
—— Ent. Soc. Wash. Proc., 5:140-148. 1903.
—— Ent. Soc. Wash. Proc., 6:37-41. 1904.
FELT, E. P. N. Y. St. Mus. Bull. 79.
—— N. Y. St. Mus. Bull. 97.
THEOBALD, F. V. Monograph.

13. **Lepidoplatys squamiger** Coq. (*deniedmannii* Ludlow).

ALDRICH, J. M. Cat. Diptera, p. 131.
COQUILLETT, D. W. U. S. N. M. Proc., 25:84-85.
DYAR, H. G. Jour. N. Y. Ent. Soc., 13:22, 187. 1905.
FELT, E. P. N. Y. St. Mus. Bull. 79.
QUAYLE, H. J. Can. Ent., Jan. 1906.
SMITH, J. B. N. J. Ex. Sta. Rept., p. 221.

14. **Psorophora ciliata** Fabr. (*molesta* Wied., *rubida* Desv.).

ALDRICH, J. M. Cat. Diptera, p. 124. 1905.
DYAR, H. G. Jour. N. Y. Ent. Soc., 13:23. 1905.
HARRIS, H. T. Ent. News, 14:232-233. 1903.
FELT, E. P. N. Y. St. Mus. Bull. 79.
—— N. Y. St. Mus. Bull. 97.
GARMAN, H. Kentucky Ex. Sta. Bull. 96.
GILES, G. M. Gnats or Mosquitoes, p. 345. 1900.
HOWARD, L. O. Can. Ent., 32:353.
JOHANNSEN, O. S. N. Y. St. Mus. Bull. 68.
ROBINSON, W. F. Rept. Eliz. N. J. 1903.
THEOBALD, F. V. Monograph.

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1900. Report of the Agricultural Experiment Station for the year 1897-98.
1902. Report of the Agricultural Experiment Station for 1898-1901.
1903. Report of the Agricultural Experiment Station for 1901-1903.
1904. Twenty-second Report of the Agricultral Experiment Station for 1903-1904.

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171. Commercial Fertilizers. (June 30, 1905.)
172. Further Experience in Asparagus Rust Control.
173. Commercial Fertilizers. (December, 1905.)
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175. Tomato Diseases in California.
176. Sugar Beets in the San Joaquin Valley.
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